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Hiroko YAMAZAKI et al.	)
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For: Electronic Apparatus	)

VERIFICATION OF TRANSLATION

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Sir:

I, Miwako Iwata, C/O Semiconductor Energy Laboratory Co., Ltd. 398, Hase, Atsugi-shi, Kanagawa-ken 243-0036 Japan, a translator, herewith declare:

that I am well acquainted with both the Japanese and English Languages;

that I am the translator of the attached English translation of the Japanese Patent Application No. 2003-103114 filed on April 7, 2003; and

that to the best of my knowledge and belief the following is a true and correct English translation of the Japanese Patent Application No. 2003-103114 filed on April 7, 2003.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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[List of Attachment]

[Attachment] Specification 1

[Attachment] Drawing 1

[Attachment] Abstract 1

[Proof] required

[Name of Document] Specification

[Title of the Invention] Electronic Apparatus

[Scope of Claims]

[Claim 1]

An electronic apparatus using a light emitting device, characterized in that:

the light emitting device comprises a light emitting element, a color filter provided on one side of an anode and a cathode of the light emitting element, and two polarizing plates sandwiching the light emitting element and the color filter;

the anode and the cathode have light transmitting properties;

deflection angles of the two polarizing plates are different from each other; and

light obtained from the light emitting element is white.

[Claim 2]

An electronic apparatus using a light emitting device, characterized in that:

the light emitting device comprises a light emitting element, two color filters sandwiching the light emitting element, and two polarizing plates sandwiching the light emitting element and the two color filters;

the anode and the cathode have light transmitting properties;

deflection angles of the two polarizing plates are different from each other; and

light obtained from the light emitting element is white.

[Claim 3]

An electronic apparatus using a light emitting device, characterized in that:

the light emitting device comprises a light emitting element, a first transistor for determining a current value supplied to the light emitting element, a second transistor for selecting emission or non-emission of the light emitting element, a color filter provided on one side of an anode and a cathode of the light emitting element, and two polarizing plates sandwiching the light emitting element and the color filter;

the anode and the cathode have light transmitting properties;

deflection angles of the two polarizing plates are different from each other;

light obtained from the light emitting element is white;

the light emitting element, the first transistor, and the second transistor are connected in series between a first power supply and a second power supply; and

a gate of the first transistor is connected to a third power supply.

[Claim 4]

An electronic apparatus using a light emitting device, characterized in that:

the light emitting device comprises a light emitting element, a first transistor for determining a current value supplied to the light emitting element, a second transistor for selecting emission or non-emission of the light emitting element, two color filters sandwiching the light emitting element, and two polarizing plates sandwiching the light emitting element and the two color filters;

the anode and the cathode have light transmitting properties;

deflection angles of the two polarizing plates are different from each other;

light obtained from the light emitting element is white;

the light emitting element, the first transistor, and the second transistor are connected in series between a first power supply and a second power supply; and

a gate of the first transistor is connected to a third power supply.

[Claim 5]

An electronic apparatus using a light emitting device, characterized in that:

the light emitting device comprises a light emitting element, a color filter provided on one side of an anode and a cathode of the light emitting element, and two liquid crystal panels sandwiching the light emitting element and the color filter;

the anode and the cathode have light transmitting properties; and

light obtained from the light emitting element is white.

[Claim 6]

An electronic apparatus using a light emitting device, characterized in that:

the light emitting device comprises a light emitting element, two color filters

sandwiching the light emitting element, and two liquid crystal panels sandwiching the light emitting element and the two color filters;

the anode and the cathode have light transmitting properties; and

light obtained from the light emitting element is white.

[Claim 7]

An electronic apparatus using a light emitting device, characterized in that:

the light emitting device comprises a light emitting element, a first transistor for determining a current value supplied to the light emitting element, a second transistor for selecting emission or non-emission of the light emitting element, a color filter provided on one side of an anode and a cathode of the light emitting element, and two liquid crystal panels sandwiching the light emitting element and the color filter;

the anode and the cathode have light transmitting properties;

light obtained from the light emitting element is white;

the light emitting element, the first transistor, and the second transistor are connected in series between a first power supply and a second power supply; and

a gate of the first transistor is connected to a third power supply.

[Claim 8]

An electronic apparatus using a light emitting device, characterized in that:

the light emitting device comprises a light emitting element, a first transistor for determining a current value supplied to the light emitting element, a second transistor for selecting emission or non-emission of the light emitting element, two color filters sandwiching the light emitting element, and two liquid crystal panels sandwiching the light emitting element and the two color filters;

the anode and the cathode have light transmitting properties;

light obtained from the light emitting element is white;

the light emitting element, the first transistor, and the second transistor are connected in series between a first power supply and a second power supply; and

a gate of the first transistor is connected to a third power supply.

[Claim 9]

The electronic apparatus according to any one of claims 1 to 8, characterized in that:

the light emitting element comprises a first light emitting layer which exhibits blue emission and a second light emitting layer, the second light emitting layer having a phosphorescent material which is dispersed in a host material with a concentration of 10 wt % or more, and exhibiting both phosphorescence from the phosphorescent material and emission from the phosphorescent material in an excimer state.

[Claim 10]

The electronic apparatus according to claim 9, characterized in that the highest peak in the emission spectrum of the first light emitting layer is positioned in a region from 400 nm to 500 nm.

[Claim 11]

The electronic apparatus according to claim 9 or 10, characterized in that the phosphorescent material exhibits emission having two or more peaks in a region from 500 nm to 700 nm, and one of the two or more peaks corresponds to the excimer emission.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Pertains]

The present invention relates to an electronic apparatus using a light emitting device, and more particularly to a portable electronic apparatus.

[0002]

[Conventional Art]

Portable electronic apparatuses typified by portable phones, electronic databooks, and the like have been required to be equipped with various functions such as transmission/reception of e-mail, voice recognition, or image pickup with a small-size camera as well as a display device for displaying images, while there have been a strong demand of users for downsizing and weight saving of such apparatuses. Therefore, it is required that a larger number of ICs having a larger circuit scale and higher memory capacity be formed in a limited volume of the portable electronic apparatus. In order to achieve higher performance of the portable electronic apparatus with an enough space secured for incorporating ICs and also achieve downsizing and weight saving thereof, an essential key is to fabricate a mounted flat panel display to be as thin and light as possible.

[0003]

For example, in the case of a liquid crystal display device which is comparatively often used for a portable electronic apparatus, a light source, an optical waveguide, and the like are required when it is of a light transmissive type, which prevents the thinner shape and weight saving. Meanwhile, in the case of a reflective type which utilizes outside light, an image cannot be easily recognized in a dark place, which makes it difficult to take the advantage of a portable electronic apparatus in its usability in any place. In recent years, a light emitting device which uses light emitting elements as display elements has been examined to be mounted on a portable electronic apparatus, and has been put into practical use. Since a light emitting element emits light by itself, it can display a clear image in a dark place without the need of a light source, unlike the case of using a liquid crystal display device. Accordingly, there is no need of using a backlight component such as a light source and an optical waveguide, which enables the thinner shape and weight saving of the display device.

[0004]

It should be noted that the light emitting device includes a light emitting panel in a state of being sealed with light emitting elements, and a module in a state where an IC or the like including a controller is mounted on the panel.

[0005]

[Problems to be Solved by the Invention]

By using a light emitting device in this manner, higher performance, downsizing, and weight saving of a portable electronic apparatus can be achieved, while there remains a problem concerning how a display screen can be enlarged. One of the reasons is that a larger volume of information is required to be displayed in accordance with the higher performance of a portable electronic apparatus. Besides, there is another reason that the demand for a portable electronic apparatus whose displayed text size can be increased for senior citizens is increasing with the increase of the population of senior citizens.

[0006]

In view of the foregoing problems, it is an object of the invention to achieve weight saving, downsizing, and enlargement of a display screen of an electronic apparatus, in particular a portable electronic apparatus.

[0007]

[Means for Solving the Problems]

In order to solve the above problems, the invention takes the following measures. A structure of a light emitting device in which light from light emitting elements can be emitted to opposite screen sides is employed, whereby an area capable of displaying images is increased twice as large by using both the front and back screens. In the case of displaying a different image on each screen, video signals corresponding to the two screens are alternately inputted. By using the light emitting device capable of performing display on opposite screen sides in this manner, downsizing and weight saving of the light emitting device can be advanced while enlarging an area capable of displaying images.

[0008]

Further, a full color image is displayed on at least one screen of the light emitting device. Specifically, a full color image can be obtained by using a white light emitting element in each

pixel, and making light that is emitted from the light emitting element pass through a color filter. A full color display with the use of a color filter is the existing technology which has been established in a liquid crystal display device, and it has the advantage of being applied to a light emitting device easily. Further, it has another advantage that precise selective coating of electroluminescent materials with a shadow mask is not required, unlike the method of performing a full color display by using light emitting elements which correspond to the three primary colors, thus luminance variations over time is uniform among all the colors. Unlike the case of a CCM method in which blue light is converted into green or red light by using a color conversion material (CCM) formed of a fluorescent material, there is no concern that the purity of a red color might be decreased due to low color conversion efficiency, or that a pixel might emit light due to outside light such as sunlight because of the color conversion material itself being a fluorescent body, which would result in a low contrast.

[0009]

In addition, in the case of using white light emitting elements, it is possible to display a full color image on one screen side and display a monochrome image on the other screen side by providing color filters on one screen side. In this case, the number of pixels for the monochrome display can be increased three times as large as those of other methods for full color displays. It should be noted that there may be a case where the luminance of light emitting elements which is obtained through color filters may vary between each color because the light transmittance of the color filters differs between each color, or the color purity of the light emitting elements is poor. In this case, when a voltage applied to the light emitting elements is changed between each color in order to correct colors, a light emitting element to which the highest voltage is applied will degrade faster, while a light emitting element to which the lowest voltage is applied can be suppressed in its degradation; therefore, luminance variations will easily occur with the passage of light emission time. According to the invention, an image is displayed by using a light emitting element to which the lowest voltage is applied in the case of displaying a monochrome image. According to the above structure, variations in degradation of light emitting elements due to the difference in applied voltage can be suppressed.

[0010]

A TFT using polysilicon has a problem in that its characteristics easily vary due to a

defect in crystal grain boundaries. When the threshold voltage of a TFT varies, the luminance of a light emitting element whose current flow is controlled by the TFT also varies. Further, there is another problem that the luminance of a light emitting element decays with the degradation of an electroluminescent material. When the electroluminescent material degrades, the luminance decays even when a current supplied to the light emitting element is constant. The degree of degradation depends on the light emission time and the amount of a current flow. Therefore, when a gray level differs among pixels depending on the displayed image, degradation of a light emitting element in each pixel also differs, which leads to variations in luminance.

[0011]

Luminance decay with the degradation of an electroluminescent layer can be suppressed by a certain degree by operating a transistor for controlling a current value supplied to a light emitting element in the saturation region. However, since a drain current in the saturation region largely influences a flowing current with respect to a slight change in the gate-source voltage Vgs, it is required to pay attention that the gate-source voltage Vgs will not change during the period in which the light emitting element emits light. Therefore, it is required that the capacity of a capacitor provided between the gate and the source of the transistor be increased, or the off-current of a transistor for controlling an input of a video signal to a pixel be suppressed low. Further, there is another problem that the Vgs of the transistor for controlling a current value supplied to the light emitting element changes along with the switching of other transistors, a potential change of a signal line or a scan line, and the like. This results from the parasitic capacitance of the gate of the transistor.

[0012]

According to the invention, the following pixel configuration can be adopted for a light emitting device besides the above measure.

[0013]

First, in addition to a transistor for supplying a current to a light emitting element (driving transistor), a transistor which functions as a switching element (current controlling transistor) is connected to the driving transistor in series. The gate potential of the driving transistor is fixed, whereby the driving transistor is operated in the saturation region and is in the

state of being capable of constantly flowing a current. The current controlling transistor is operated in the linear region, whereby a video signal is inputted to the gate of the current controlling transistor.

[0014]

The current controlling transistor operates in the linear region; therefore, its source-drain voltage (drain voltage) Vds is quite lower relative to a voltage Vel which is applied to the light emitting element, and thus a slight change in the gate-source voltage (gate voltage) Vgs does not influence the current supplied to the light emitting element. The driving transistor operates in the saturation region; therefore, its drain current does not change by the drain voltage Vds, but is determined only by the Vgs. That is, the current controlling transistor only selects whether or not to supply a current to the light emitting element, and a current value supplied to the light emitting element is determined by the driving transistor which operates in the saturation region. Accordingly, a current supplied to the light emitting element is not influenced even without increasing the capacity of a capacitor which is provided between the gate and the source of the current controlling transistor or suppressing the off-current of the transistor which controls an input of a video signal to a pixel. In addition, the current supplied to the light emitting element is not influenced by the parasitic capacitance of the gate of the current controlling transistor. Therefore, cause of variations is decreased and image quality can thus be enhanced to a great extent. By operating the driving transistor in the saturation region, the value of the drain current is kept relatively constant even when the Vds is decreased in stead of the Vel being increased due to the degradation of the light emitting element. Accordingly, a luminance decay can be suppressed even when the light emitting element has degraded. Further, since it is not necessary to optimize the process in order to suppress off-current of the transistor for controlling an input of a video signal to a pixel, the manufacturing process of transistors can be simplified, which leads to a cost reduction and improvement in yield.

[0015]

L of the driving transistor may be longer than W thereof, and L of the current controlling transistor may be equal to or shorter than W thereof. The ratio of L to W of the driving transistor is desirably 5 : 1 or more. According to the above structure, luminance variations of light emitting elements among pixels due to the characteristic variations of driving transistors

can be suppressed.

[0016]

A transistor used in the light emitting device of the invention may be a transistor formed by using single crystalline silicon, a transistor using an SOI, or a thin film transistor using polycrystalline silicon or amorphous silicon. Alternatively, a transistor using an organic semiconductor or a transistor using carbon nanotube may be used. In addition, a transistor provided in the pixel of the light emitting device of the invention may have a single-gate structure, a double-gate structure, or a multi-gate structure having more gate electrodes.

[0017]

[Embodiment Modes of the Invention]

(Embodiment Mode 1)

A specific structure of the invention is described with reference to FIG. 1. FIG. 1(A) shows one mode of a cross sectional structure of the light emitting device of the invention. The light emitting device of the invention shown in FIG. 1(A) includes a light emitting panel 101 in which a light emitting element is disposed in each pixel, two color filters 102 and 103 sandwiching the light emitting panel 101, and two polarizing plates 104 and 105 sandwiching the light emitting panel 101 and the color filters 102 and 103.

[0018]

The light emitting panel 101 has a structure in which light from the light emitting element is emitted to the opposite sides as shown by hollow arrows. Specifically, each light emitting element employs electrodes having a light transmitting property (light transmissivity) as an anode and a cathode. The light emitting element is characterized by emitting white light. Of the light emitted from opposite sides of the light emitting panel 101, light having a wavelength within a certain range passes through the color filters 102 and 103, and further, light having a certain deflection component passes through the polarizing plates 104 and 105.

[0019]

The polarizing plates 104 and 105 are disposed so that their transmission deflection angles are different from each other, and desirably to be different by 90° so as to prevent outside light from passing through the light emitting panel. FIG. 2(A) shows the direction of the outside light which passes through a light emitting panel 101 in the case of providing no

polarizing plate. FIG. 2(B) shows the direction of the light emitted from the light emitting panel 201 in the case of sandwiching the light emitting panel 201 by two polarizing plates 202 and 203 having different deflection angles.

[0020]

In the case of providing no polarizing plate as shown in FIG. 2(A), each of an anode and a cathode of a light emitting element included in the light emitting panel 201 has a light transmitting property. Therefore, the light emitting panel 201 transmits outside light, and thus a far side of the light emitting panel 201 can be seen through by human eyes. On the other hand, in the case of providing the polarizing plates 202 and 203 as shown in FIG. 2(B), only one of the two polarizing plates 202 and 203 transmits outside light. Therefore, it is prevented that a far side of the light emitting panel 201 is seen through, and the contrast of an image can thus be enhanced. However, since a specific deflection component of the light emitted from the light emitting panel 201 passes through each of the polarizing plates 202 and 203, light can be obtained from both sides.

[0021]

FIG. 1(B) shows another mode of a cross sectional structure of the light emitting element of the invention, which is different from FIG. 1(B). The light emitting device of the invention shown in FIG. 1(B) includes a light emitting panel 111 in which a light emitting element is disposed in each pixel, two color filters 112 and 113 sandwiching the light emitting panel 111, and two liquid crystal panels 114 and 115 sandwiching the light emitting panel 111 and the color filters 112 and 113.

[0022]

As in FIG. 1(A), the light emitting panel 111 has a structure in which light from the light emitting element is emitted to opposite sides. Specifically, each light emitting element employs electrodes having a light transmitting property as an anode and a cathode. The light emitting element is characterized by emitting white light. Of the light emitted from opposite sides of the light emitting panel 111, light having a wavelength within a certain range passes through the color filters 112, and 113, and further, the light passes through only one of the liquid crystal panels 114 and 115.

[0023]

Each of the liquid crystal panels 114 and 115 includes a pixel electrode, a counter electrode, and a liquid crystal sandwiched between the pixel electrode and the counter electrode. Further, it includes a polarizing plate and the like. The light transmittance of each of the liquid crystal panels 114 and 115 is controlled by a voltage applied between the pixel electrode and the counter electrode. The two liquid crystal panels 114 and 115 are controlled to be driven in such a manner that in the period when one of them transmits light, the other does not transmit light. According to the above structure, it can be prevented that the light emitting panel transmits outside light.

[0024]

It should be noted in FIG. 1(A) and FIG. 1(B) that color filters are provided separately from the light emitting panel 101; however, a film which functions as a color filter may be provided inside the light emitting panel.

[0025]

FIG. 3(A) shows a view of a light emitting device which includes a light emitting panel 301 sandwiched between two liquid crystal panels 302 and 303, in which light is made pass through the liquid crystal panel 302. In addition, FIG. 3(B) shows a view of a light emitting device which includes the light emitting panel 301 sandwiched by the two liquid crystal panels 302 and 303, in which light is made pass through the liquid crystal panel 303.

[0026]

As shown in FIG. 3(A) and FIG. 3(B), driving is performed in such a manner that when the liquid crystal panel 302 transmits light, the liquid crystal panel 303 blocks light. Accordingly, light emitted from a light emitting element 304 of the light emitting panel 301 passes through only one side as shown by a hollow arrow. According to the above structure, it can be prevented that a far side of the light emitting panel 301 is seen through by human eyes due to the outside light passing therethrough; therefore, the contrast can be enhanced. Switching of video signals may be performed in synchronization with the switching of the light transmittance of the liquid crystal panels 302 and 303. Specifically, a video signal having image data for the side to transmit light is inputted to the light emitting panel 301 regardless of which liquid crystal panel is to transmit light. According to the above structure, different images can be displayed on opposite sides of the light emitting panel 301 in parallel.

[0027]

It should be noted that color filters are provided on opposite sides of the light emitting panel in each of FIG. 1(A) and FIG. 1(B); however, a color filter may be provided on only one side. In that case, a monochrome image is displayed on the side of the light emitting panel which is not provided with a color filter. In the case of a full color display, neutral colors are expressed by three pixels corresponding to the three primary colors of red (R), green (G), and blue (B), while in the case of a monochrome display, an image is displayed by using basically one pixel since an achromatic color is required. However, the achromatic color cannot be expressed by one pixel when using the method of performing a full color display with light emitting elements corresponding to the three primary colors or using a CCM method. Thus, in these two methods, an image is displayed by using three pixels as one unit on the side for performing a monochrome display, similarly to the side for performing a full color display. Meanwhile, since the invention employs a white light emitting element, a monochrome display can be performed with one pixel without providing a color filter on one screen side.

[0028]

It should be noted that in this embodiment mode, the light emitting panel may be either of an active matrix type or of a passive matrix type.

[0029]

As described in this embodiment mode, since the light emitting device of the invention can display images on opposite sides of the light emitting panel, downsizing and weight saving of the light emitting device can be advanced while enlarging an area capable of displaying images. The structure of the invention is effective in particular for portable electronic apparatuses, which have significance in downsizing and weight saving.

[0030]

(Embodiment Mode 2)

FIG. 4(A) shows one mode of a pixel of the light emitting device of the invention. The pixel shown in FIG. 4(A) includes a light emitting element 401, a transistor (switching transistor) 402 used as a switching element for controlling an input of a video signal to the pixel, a driving transistor 403 for controlling a current value supplied to the light emitting element 401, and a current controlling transistor 404 for selecting whether or not to supply a current to the light

emitting element 401. Further, a capacitor 405 for storing a potential of a video signal may be provided in the pixel as in this embodiment mode.

[0031]

The driving transistor 403 and the current controlling transistor 404 have the same polarity. In FIG. 4(A), both of them are of a P-type; however, they may be of an N-type. In the invention, the driving transistor 403 is operated in the saturation region, while the current controlling transistor 404 is operated in the linear region. A channel length L of the driving transistor 403 may be longer than a channel width W thereof. L of the current controlling transistor 404 may be equal to or shorter than W thereof. More desirably, the ratio of L to W of the driving transistor 403 is 5 : 1 or more. As the driving transistor 403, either an enhancement mode transistor or a depletion mode transistor may be employed.

[0032]

The gate of the switching transistor 402 is connected to a scan line Gj (j = 1 to y). One of the source and the drain of the switching transistor 402 is connected to a signal line Si (i = 1 to x) and the other is connected to the gate of the current controlling transistor 404. The gate of the driving transistor 403 is connected to a second power supply line Wi (i = 1 to x). The driving transistor 403 and the current controlling transistor 404 are connected to a first power supply line Vi (i = 1 to x) and the light emitting element 401 so that a current supplied from the first power supply line Vi (i = 1 to x) is supplied to the light emitting element 401 as drain currents of the driving transistor 403 and the current controlling transistor 404. In this embodiment mode, the source of the current controlling transistor 404 is connected to the first power supply line Vi (i = 1 to x), while the drain of the driving transistor 403 is connected to a pixel electrode of the light emitting element 401.

[0033]

It should be noted that the source of the driving transistor 403 may be connected to the first power supply line Vi (i = 1 to x), while the drain of the current controlling transistor 404 may be connected to the pixel electrode of the light emitting element 401. In that case, a depletion mode transistor is used as the driving transistor 403.

[0034]

The light emitting element 401 includes an anode, a cathode, and an electroluminescent

layer sandwiched between the anode and the cathode. As shown in FIG. 4(A), in the case where the anode is connected to the driving transistor 403, the anode is the pixel electrode and the cathode is the counter electrode. The counter electrode of the light emitting element 401 and the first power supply line Vi (i = 1 to x) have a potential difference so that a forward bias current is supplied to the light emitting element 401.

[0035]

One of the two electrodes of the capacitor 405 is connected to the first power supply line Vi (i = 1 to x) and the other is connected to the gate of the current controlling transistor 404. The capacitor 405 is provided so as to hold a potential difference between the electrodes of the capacitor 405 when the switching transistor 402 is in a non-selected state (OFF state). It should be noted that FIG. 4(A) shows a configuration having the capacitor 405; however, the invention is not limited to this and the capacitor 405 may be omitted.

[0036]

In FIG. 4(A), the driving transistor 403 and the current controlling transistor 404 are P-channel transistors, and the drain of the driving transistor 403 and the anode of the light emitting element 401 are connected. On the other hand, when the driving transistor 403 and the current controlling transistor 404 are N-channel transistors, the source of the driving transistor 403 and the cathode of the light emitting element 401 are connected. In this case, the cathode of the light emitting element 401 is the pixel electrode and the anode thereof is the counter electrode.

[0037]

Next, a driving method of the pixel shown in FIG. 4(A) is described. The operation of the pixel shown in FIG. 4(A) can be described by dividing it into a writing period and a holding period. First, in the writing period, when the scan line Gj (j = 1 to y) is selected, the switching transistor 402 whose gate is connected to the scan line Gj (j = 1 to y) is turned ON. Then, a video signal inputted to signal lines Si to Sx is inputted to the gate of the current controlling transistor 404 through the switching transistor 402. It should be noted that the driving transistor 403 is constantly in an ON state since its gate is connected to the first power supply line Vi (i = 1 to x).

[0038]

When the current controlling transistor 404 is turned ON by a video signal, a current is supplied to the light emitting element 401 through the first power supply line Vi (i = 1 to x). The current controlling transistor 404 at this time operates in the linear region; therefore, a current supplied to the light emitting element 401 is determined by the V-I characteristics of the driving transistor 403 which operates in the saturation region and the light emitting element 401. The light emitting element 401 emits light at a luminance corresponding to the current supplied. When the current controlling transistor 404 is turned OFF by a video signal, a current supply to the light emitting element 401 is not performed, and thus the light emitting element 401 does not emit light.

[0039]

In the holding period, the switching transistor 402 is turned OFF by controlling a potential of the scan line Gj (j = 1 to y), and a potential of the video signal which is written in the writing period is held. When the current controlling transistor 404 is turned ON in the writing period, a current supply to the light emitting element 401 is kept on since the potential of the video signal is held by the capacitor 405. On the other hand, when the current controlling transistor 404 is turned OFF in the writing period, a current supply to the light emitting element 401 is not performed since the potential of the video signal is held by the capacitor 405.

[0040]

The current controlling transistor 404 operates in the linear region; therefore, its source-drain voltage (drain voltage) Vds is much lower than the voltage Vel which is applied to the light emitting element, and thus a slight change in the gate-source voltage (gate voltage) Vgs does not influence the current supplied to the light emitting element 401. In addition, the driving transistor 403 operates in the saturation region; therefore, its drain current does not change by the drain voltage Vds, but is determined only by the Vgs. Therefore, the current controlling transistor 404 only selects whether or not to supply a current to the light emitting element 401, and a current value supplied to the light emitting element 401 is determined by the driving transistor 403 which operates in the saturation region. Accordingly, changes in current supplied to the light emitting element 401 can be suppressed even without increasing the capacity of the capacitor 405 which is provided between the gate and the source of the current controlling transistor 404 or suppressing the off-current of the switching transistor 402. By

operating the driving transistor 403 in the saturation region, a value of the drain current is kept relatively constant even when the Vds is decreased instead of the Vel is increased due to the degradation of the light emitting element 401. Accordingly, luminance decay can be suppressed even when the light emitting element 401 has degraded.

[0041]

L of the driving transistor may be longer than W thereof, and L of the current controlling transistor may be equal to or shorter than W thereof. More desirably, the ratio of L to W of the driving transistor is 5 : 1 or more. According to the above structure, luminance variations of light emitting elements among pixels due to the characteristic variations of driving transistors can be suppressed.

[0042]

(Embodiment Mode 3)

In this embodiment mode, one mode of a pixel of the light emitting device of the invention is described, which is different from that in FIG. 4(A).

[0043]

The pixel shown in FIG. 4(B) includes a light emitting element 411, a switching transistor 412, a driving transistor 413, a current controlling transistor 414, and a transistor (erasing transistor) 416 for erasing a potential of a written video signal. In addition to the above elements, a capacitor 415 may be provided in the pixel. The driving transistor 413 and the current controlling transistor 414 have the same polarity. In the invention, the driving transistor 413 is operated in the saturation region, while the current controlling transistor 414 is operated in the linear region. L of the driving transistor 413 may be longer than W thereof. L of the current controlling transistor 414 may be equal to or shorter than W thereof. More desirably, the ratio of L to W of the driving transistor 413 is 5 : 1 or more.

[0044]

As the driving transistor 413, either an enhancement mode transistor or a depletion mode transistor may be employed.

[0045]

The gate of the switching transistor 412 is connected to a first scan line Gaj (j = 1 to y). One of the source and the drain of the switching transistor 412 is connected to the signal line Si

(i = 1 to x) and the other is connected to the gate of the current controlling transistor 414. The gate of the erasing transistor 416 is connected to a second scan line Gej (j = 1 to y), and one of the source and the drain thereof is connected to the first power supply line Vi (i = 1 to x), while the other is connected to the gate of the current controlling transistor 414. The gate of the driving transistor 413 is connected to the second power supply line Wi (i = 1 to x). The driving transistor 413 and the current controlling transistor 414 are connected to the first power supply line Vi (i = 1 to x) and the light emitting element 411 so that a current supplied from the first power supply line Vi (i = 1 to x) is supplied to the light emitting element 411 as drain currents of the driving transistor 413 and the current controlling transistor 414. In this embodiment mode, the source of the current controlling transistor 414 is connected to the first power supply line Vi (i = 1 to x), while the drain of the driving transistor 413 is connected to a pixel electrode of the light emitting element 411. It is also possible to connect the source of the driving transistor 413 to the first power supply line Vi (i = 1 to x) and to connect the drain of the current controlling transistor 414 to the pixel electrode of the light emitting element 411.

[0046]

The light emitting element 411 includes an anode, a cathode, and an electroluminescent layer sandwiched between the anode and the cathode. As shown in FIG. 4(B), in the case where the anode is connected to the driving transistor 413, the anode is the pixel electrode and the cathode is the counter electrode. The counter electrode of the light emitting element 411 and the first power supply line Vi (i = 1 to x) have a potential difference so that a forward bias current is supplied to the light emitting element 411.

[0047]

One of the two electrodes of the capacitor 415 is connected to the first power supply line Vi (i = 1 to x) and the other is connected to the gate of the current controlling transistor 414.

[0048]

In FIG. 4(B), the driving transistor 413 and the current controlling transistor 414 are P-channel transistors, and the drain of the driving transistor 413 is connected to the anode of the light emitting element 411. On the other hand, when the driving transistor 413 and the current controlling transistor 414 are N-channel transistors, the source of the driving transistor 413 and the cathode of the light emitting element 411 are connected. In this case, the cathode of the

light emitting element 411 is the pixel electrode and the anode thereof is the counter electrode.

[0049]

The operation of the pixel shown in FIG. 4(B) can be described by dividing it into a writing period, a holding period, and an erasing period. The operation of the switching transistor 412, the driving transistor 413, and the current controlling transistor 414 in the writing period and the holding period are the same as that in FIG. 4(A).

[0050]

In the erasing period, a second scan line Gej (j = 1 to y) is selected and the erasing transistor 416 is turned ON. Then, the potential of the power supply lines V1 to Vx is supplied to the gate of the current controlling transistor 414 through the erasing transistor 416. Thus, the current controlling transistor 414 is turned OFF, and it becomes possible to forcibly produce a state in which no current is supplied to the light emitting element 411.

[0051]

[Embodiments]

Embodiments of the invention will be described below.

[0052]

(Embodiment 1)

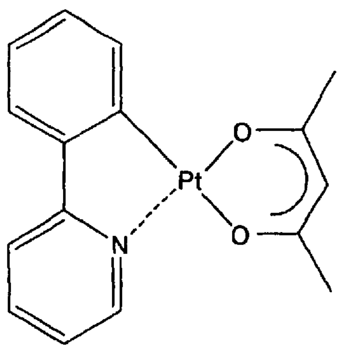
In this embodiment, one configuration example of a light emitting element used in the light emitting device of the invention is described.

[0053]

FIG. 5(A) schematically shows a cross sectional structure of a light emitting element which is included in the light emitting device of the invention. As a structure of the element, a hole injection layer 502 which includes copper phthalocyanine (CuPc), a first light emitting layer 503 which includes 4,4'-bis[*N*-(1-naphthyl)-*N*-phenyl-amino]-biphenyl (abbreviated to a-NPD), a second light emitting layer 504 which includes 4,4'-*N*,*N*'-dicarbazolyl-biphenyl (abbreviated to CBP) as a guest material and also includes Pt(ppy)acac as a host material, an electron injection layer 506 which includes CaF_2, and a cathode 507 which includes Al are sequentially stacked over an anode 501 formed of ITO as a transparent conductive film. Note that Pt(ppy)acac can be expressed by the following Formula 1.

[0054]

[Formula 1]



[0055]

According to the invention, dual emission can be realized by forming the cathode 507 to be thin enough to transmit light, specifically, to be about 20 nm thick.

[0056]

In the second light emitting layer 504 of the light emitting element shown in FIG. 5(A), when CBP which is a phosphorescent material is dispersed as the guest material into Pt(ppy)acac which is the host material, with a concentration of 10 wt % or more, both of phosphorescence from the phosphorescent material and light emission from the phosphorescent material in the excimer state can be obtained. Specifically, the phosphorescent material exhibits light emission having two or more peaks in the region from 500 nm to 700 nm, and it is desirable that one of the two or more peaks corresponds to the excimer emission. The first light emitting layer 503 exhibits blue light emission whose emission spectrum has the highest peak in the region from 400 nm to 500 nm. When the blue light emission is mixed with the light emission from the second light emitting layer, white light emission having a color purity which is quite close to 0 can be obtained. In addition, since only one kind of dopant is used, stable white light emission can be supplied without a change in the shape of the emission spectrum even when a current density is changed or in the case of performing a continuous drive. It should noted that the first light emitting layer may also have a structure where, in a host material, a guest material which exhibits blue light emission whose emission spectrum has the highest peak in the region from 400 nm to 500 nm is dispersed.

[0057]

FIG. 5(B) schematically shows a cross sectional structure of a light emitting element

which is included in the light emitting device of the invention, which is different from FIG. 5(A). As a structure of the element, a hole injection layer 512 which includes polythiophene, a hole transporting layer 513 which includes *N,N'*-bis(3-methylphenyl)-*N,N'*-diphenyl-1,1'-biphenyl-4,4'-diamine (abbreviated to TPD), a first light emitting layer 514 which includes rubrene as a guest material and also includes TPD as a host material, a second light emitting layer 515 which includes coumarin 6 as a guest material and also includes Alq_3 as a host material, and a cathode 516 which includes Al are sequentially stacked over an anode 511 which is formed of ITO as a transparent conductive film.

[0058]

In FIG. 5(B) also, dual emission of white light can be realized by forming the cathode 516 to be thin enough to transmit light, specifically, to be about 20 nm thick.

[0059]

FIG. 5(C) schematically shows a cross sectional structure of a light emitting element which is included in the light emitting device of the invention, which is different from FIG. 5(A). As a structure of the element, a hole injection layer 522 which includes HIM34, a hole transporting layer 523 which includes a tetraaryl benzidine derivative, a first light emitting layer 524 which includes a naphthacene derivative as a guest material and also includes a tetraaryl benzidine derivative and a phenyl anthracene derivative as host materials, a second light emitting layer 525 which includes a styryl amine derivative as a guest material and also includes a tetraaryl benzidine derivative and a phenyl anthracene derivative as host materials, an electron transporting layer 526 which includes a phenyl anthracene derivative, an electron injection layer 527 which includes Alq_3, a first cathode 528 which includes CsI, and a second cathode 529 which includes MgAg are sequentially stacked over an anode 521 which is formed of ITO as a transparent conductive film.

[0060]

In FIG. 5(C) also, dual emission of white light can be realized by forming the first cathode 528 and the second cathode 529 to have a total thickness that is thin enough to transmit light, specifically, to be about 20 nm thick.

[0061]

It should be noted that the stacked structure of the light emitting element in this

embodiment mode is not limited to those shown in FIG. 5. In order to obtain light from the cathode side, there is a method of using ITO which is doped with Li to be reduced in work function, besides the method of reducing the film thickness. It is acceptable as long as a light emitting element used in the invention has at least a structure where light is emitted to both sides of the anode and the cathode.

[0062]

(Embodiment 2)

In this embodiment, one embodiment of a pixel of the light emitting device of the invention which is described in Embodiment Mode 1 is described.

[0063]

FIG. 6(A) shows a circuit diagram of a pixel of this embodiment. In FIG. 6(A), reference numeral 601 denotes a switching transistor. The gate of the switching transistor 601 is connected to the scan line Gj (j = 1 to y). One of the source and the drain of the switching transistor 601 is connected to the signal line Si (i = 1 to x) and the other is connected to the gate of a driving transistor 602. One of the source and the drain of the driving transistor 602 is connected to the power supply line Vi (i = 1 to x) and the other is connected to a pixel electrode of a light emitting element 603.

[0064]

The light emitting element 603 includes an anode, a cathode, and an electroluminescent layer sandwiched between the anode and the cathode. In the case where the anode is connected to the source or the drain of the driving transistor 602, the anode is the pixel electrode and the cathode is a counter electrode. On the other hand, in the case where the cathode is connected to the source or the drain of the driving transistor 602, the cathode is the pixel electrode and the anode is the counter electrode. It should be noted that the driving transistor 602 is desirably a P-channel transistor when the source or the drain of the driving transistor 602 is connected to the anode of the light emitting element 603. Meanwhile, the driving transistor 602 is desirably an N-channel transistor when the source or the drain of the driving transistor 602 is connected to the cathode of the light emitting element 603.

[0065]

Each of the counter electrode of the light emitting element 603 and the power supply

line Vi is supplied with a voltage from a power supply. A voltage difference between the counter electrode and the power supply line is kept at a level which enables a forward bias voltage to be applied to the light emitting element when the driving transistor is turned ON.

[0066]

One of the two electrodes of a capacitor 604 is connected to the power supply line Vi and the other is connected to the gate of the driving transistor 602. The capacitor 604 is provided so as to hold the gate voltage of the driving transistor 602 when the switching transistor 601 is in a non-selected state (OFF state). It should be noted that FIG. 6(A) shows a configuration having the capacitor 604; however, the invention is not limited to this and the capacitor 604 may be omitted.

[0067]

When the switching transistor 601 is turned ON by a potential of the scan line Gj, a potential of a video signal which is inputted to the signal line Si is supplied to the gate of the driving transistor 602. According to the potential of the inputted video signal, the gate voltage (voltage difference between the gate and the source) of the driving transistor 602 is determined. The drain current of the driving transistor 602 which flows by the gate voltage is then supplied to the light emitting element 603, thus the light emitting element 603 emits light in accordance with the supplied current.

[0068]

FIG. 6(B) shows a pixel configuration which is different from FIG. 6(A). In FIG. 6(B), reference numeral 611 denotes a switching transistor. The gate of the switching transistor 611 is connected to the first scan line Gaj (j = 1 to y). One of the source and the drain of the switching transistor 611 is connected to the signal line Si (i = 1 to x) and the other is connected to the gate of a driving transistor 612. The gate of an erasing transistor 614 is connected to the second scan line Gej (j = 1 to y). One of the source and the drain of the erasing transistor 614 is connected to the power supply line Vi (i = 1 to x) and the other is connected to the gate of the driving transistor 612. One of the source and the drain of the driving transistor 612 is connected to the power supply line Vi and the other is connected to a pixel electrode of a light emitting element 613.

[0069]

The light emitting element 613 includes an anode, a cathode, and an electroluminescent layer sandwiched between the anode and the cathode. In the case where the anode is connected to the source or the drain of the driving transistor 612, the anode is the pixel electrode and the cathode is a counter electrode. On the other hand, in the case where the cathode is connected to the source or the drain of the driving transistor 612, the cathode is the pixel electrode and the anode is the counter electrode. The driving transistor 612 is desirably a P-channel transistor when the anode is the pixel electrode. On the other hand, the driving transistor 612 is desirably an N-channel transistor when the cathode is the pixel electrode. Each of the counter electrode of the light emitting element 613 and the power supply line Vi is supplied with a voltage from a power supply. A voltage difference between the counter electrode and the power supply line is kept at a level which enables a forward bias voltage to be applied to the light emitting element when the driving transistor is turned ON.

[0070]

One of the two electrodes of a capacitor 615 is connected to the power supply line Vi and the other is connected to the gate of the driving transistor 612. The capacitor 615 is provided so as to hold the gate voltage of the driving transistor 612 when the switching transistor 611 is in a non-selected state (OFF state). It should be noted that FIG. 6(B) shows a configuration having the capacitor 615; however, the invention is not limited to this and the capacitor 615 may be omitted.

[0071]

When the switching transistor 611 is turned ON by a potential of the first scan line Gaj, a potential of a video signal which is inputted to the signal line Si is supplied to the gate of the driving transistor 612. According to the potential of the inputted video signal, the gate voltage (voltage difference between the gate and the source) of the driving transistor 612 is determined. The drain current of the driving transistor 612 which flows by the gate voltage is then supplied to the light emitting element 613, thus the light emitting element 613 emits light in accordance with the supplied current.

[0072]

Further, when the erasing transistor 614 is turned ON by a potential of the second scan line Gej, a potential of the power supply line Vi is supplied to both the gate and the source of the

driving transistor 612. Thus, the driving transistor 612 is turned OFF, and the emission of the light emitting element 613 is forcibly terminated.

[0073]

In the case of using the pixels shown in FIG. 6, the video signal may be either an analog signal or a digital signal. In the case of a digital signal, a gray level can be expressed by controlling the period in which a light emitting element emits light (light emission period). However, the light emitting element shown in FIG. 5(A) can be said to be also effective for analog drive because stable white light emission can be supplied without a change in the shape of the emission spectrum even when a current density is changed.

[0074]

The structure shown in this embodiment is only one example of the light emitting device of the invention; therefore, the invention is not limited to this structure. In addition, although FIG. 6 employs a type in which a video signal is inputted with a voltage, the invention can also be applied to a light emitting device of a type in which a video signal is inputted with a current.

[0075]

(Embodiment 3)

A cross sectional structure of a pixel of the light emitting device of the invention is described with reference to FIG. 7. In FIG. 7, a transistor 6001 is formed over a substrate 6000. The transistor 6001 is covered with a first interlayer insulating film 6002. Over the first interlayer insulating film 6002, a color filter 6003 which is formed of resin or the like and a wiring 6004 which is electrically connected to the transistor 6001 through a contact hole are formed.

[0076]

Then, a second interlayer insulating film 6005 is formed over the first interlayer insulating film 6002 so as to cover the resin film 6003 and the wiring 6004. It should be noted that the first interlayer insulating film 6002 or the second interlayer insulating film 6005 may be formed by stacking silicon oxide, silicon nitride, or silicon oxynitride in a single layer or multiple layers by using a plasma CVD method or a sputtering method. Alternatively, a stacked film in which a silicon oxynitride film having a higher mole fraction of oxygen than that of

nitrogen is stacked over a silicon oxynitride film having a higher mole fraction of nitrogen than that of oxygen may be used as the first interlayer insulating film 6002 or the second interlayer insulating film 6005. Alternatively, an organic resin film may be used as the first interlayer insulating film 6002 or the second interlayer insulating film 6005.

[0077]

On the second interlayer insulating film 6005, a wiring 6006 which is electrically connected to the wiring 6004 through a contact hole and an anode 6007 which is electrically connected to the wiring 6006 are formed. The anode 6007 is formed in the position which overlaps with the color filter 6003 with the second interlayer insulating film 6005 interposed therebetween.

[0078]

Over the second interlayer insulating 6005, an organic resin film 6008 to be used as a bank is formed. The organic resin film 6008 has an opening, and in the opening, the anode 6007, an electroluminescent layer 6009, and a cathode 6010 are overlapped with each other so as to form a light emitting element 6011. The electroluminescent layer 6009 has a single light emitting layer or multiple stacked layers including a light emitting layer. It should be noted that a passivation film may be deposited over the organic resin film 6008 and the cathode 6010. In this case, for the passivation film, a film that has lower permeability of substances such as moisture and oxygen, which would otherwise cause deterioration of the light emitting element, in comparison with other insulating films is used. Typically, a DLC film, a carbon nitride film, a silicon nitride film formed by an RF sputtering method, or the like is desirably used, for example. Alternatively, the passivation film may be provided by stacking the above-described film that has low permeability of substances such as moisture and oxygen, and a film that has higher permeability of substances such as moisture and oxygen in comparison with the above film.

[0079]

The organic resin film 6008 is, before the electroluminescent layer 6009 is formed, heated under a vacuum atmosphere in order to remove the adsorbed moisture, oxygen, and the like. Specifically, heat treatment is applied under a vacuum atmosphere at a temperature of 100 ^{o}C to 200 ^{o}C for about 0.5 to 1 hour. The vacuum is desirably set at 3×10^{-7} Torr or less, and if possible, most desirably at 3×10^{-8} Torr or less. In the case of depositing the

electroluminescent layer after applying heat treatment to the organic resin film under the vacuum atmosphere, the reliability can be further enhanced by maintaining the vacuum atmosphere until immediately before the film deposition.

[0080]

The edge of the opening in the organic resin film 6008 is desirably formed to be roundish so that the electroluminescent layer 6009 which is formed to be partially overlapped with the organic resin film 6008 will have no holes at the edge. Specifically, it is desirable that a curved line depicted by the cross section of the organic resin film at the opening have a curvature radius in the range of 0.2 to 2 μm.

[0081]

According to the above structure, the coverage with the electroluminescent layer and the cathode which are to be formed later can be enhanced, and it can be prevented that the anode 6007 and the cathode 6010 are short-circuited in a hole formed in the electroluminescent layer 6009. Moreover, by alleviating the stress of the electroluminescent layer 6009, a defect called shrink, in which a light emitting region decreases, can be reduced and the reliability can thus be enhanced.

[0082]

In FIG. 7, an example where a positive photosensitive acrylic resin is used as the organic resin film 6008 is shown. Photosensitive organic resin is categorized as a positive type in which a portion exposed to an energy beam such as photons, electrons, or ions is removed, or a negative type in which the portion exposed remains intact. In the invention, a negative organic resin film may be used as well. In addition, the organic resin film 6008 may be formed by using photosensitive polyimide. When the organic resin film 6008 is formed by using negative acrylic, the edge of the opening has a shape of S-shaped cross-section. It is desirable that the curvature radius of the opening at an upper edge and a lower edge be in the range of 0.2 to 2 μm.

[0083]

The anode 6007 can be formed using a transparent conductive film. For example, as well as ITO, a transparent conductive film in which indium oxide is mixed with 2 to 20 % of zinc oxide (ZnO) can be used. FIG. 7 employs ITO as the anode 6007. The anode 6007 may be polished by a CMP method or by polishing with a polyvinyl-alcohol-based porous body so that

the surface is planarized. After polishing the surface of the anode 6007 by the CMP method, it may be subjected to ultraviolet irradiation, oxygen plasma treatment, or the like.

[0084]

The cathode 6010 is formed thin enough to transmit light, and any known material can be used as long as it is a conductive film having a low work function. For example, Ca, Al, CaF, MgAg, AlLi, and the like are preferably used. In order to obtain light emitted from the cathode side, there is a method of employing ITO which is doped with Li to be reduced in work function may be used, besides the method of reducing the film thickness. It is acceptable as long as a light emitting element used in the invention has at least a structure where light is emitted to both sides of the anode and the cathode.

[0085]

Practically, when the device is completed up to the stage shown in FIG. 7, a passivation film (laminate film, ultraviolet curable resin film, or the like) having good airtightness and less degasification or a light transmissive covering material 6012 is desirably used to package (seal) the device without exposing it to the air. At that time, the reliability of the OLED is enhanced by filling the inside of the covering material with an inert atmosphere or providing a moisture absorbent material (e.g., barium oxide) inside. In the invention, the covering material 6012 is provided with a color filter 6013.

[0086]

The invention is not limited to the above manufacturing method. Any known method can be used for the manufacture.

[0087]

(Embodiment 4)

In this embodiment, a configuration of the light emitting device of the invention is described. FIG. 8(A) shows a block diagram of the light emitting device of this embodiment. The light emitting device shown in FIG. 8(A) includes a pixel portion 801 in which multiple pixels each having a light emitting element are disposed, a scan line driver circuit 802 for selecting each pixel, and a signal line driver circuit 803 for controlling an input of a video signal to the selected pixel.

[0088]

In FIG. 8(A), the signal line driver circuit 803 includes a shift register 804, a level shifter 805, and a buffer 806. The shift register 804 is inputted with a clock signal (CLK), a start pulse signal (SP), and a switch signal (L/R). When the clock signal (CLK) and the start pulse signal (SP) are inputted, a timing signal is generated in the shift register 804, which is then inputted to the level shifter 805. According to the switch signal (L/R), the order in which pulses of the timing signal appear is switched.

[0089]

The timing signal is adjusted in pulse level in the level shifter 805, and then inputted to the buffer 806. In the buffer 806, a video signal (video signal) is sampled in synchronization with a pulse of the inputted timing signal, and it is inputted to the pixel portion 801 through a signal line.

[0090]

Next, a configuration of the scan line driver circuit 802 is described. The scan line driver circuit 802 includes a shift register 807 and a buffer 808. It may also include a level shifter according to the circumstances. When a clock signal CLK and a start pulse signal SP are inputted to the shift register 807 in the scan line driver circuit 802, a selection signal is generated. The generated selection signal is buffer-amplified in the buffer 808, and then supplied to a corresponding scan line. A scan line is connected to gates of transistors in one line of the pixels. Since the transistors in one line of the pixels are required to be turned ON at the same time, the buffer 808 is required to be capable of flowing a large current.

[0091]

It should be noted that an alternative circuit capable of selecting a signal line such as a decoder circuit may be used instead of the shift registers 804 and 806.

[0092]

The signal line driver circuit for driving the light emitting device of the invention is not limited to the configuration shown in this embodiment.

[0093]

(Embodiment 5)

In this embodiment, a configuration of the light emitting device of the invention is

described. FIG. 8(B) shows a block diagram of the light emitting device of this embodiment. The light emitting device shown in FIG. 8(B) includes a pixel portion 811 in which multiple pixels each having a light emitting element are disposed, a scan line driver circuit 812 for selecting each pixel, and a signal line driver circuit 813 for controlling an input of a video signal to the selected pixel.

[0094]

In FIG. 8(B), the signal line driver circuit 813 includes a shift register 814, a latch A815, and a latch B816. The shift register 814 is inputted with a clock signal (CLK), a start pulse signal (SP), and a switch signal (L/R). When the clock signal (CLK) and the start pulse signal (SP) are inputted, a timing signal is generated in the shift register 814. According to the switch signal (L/R), the order in which pulses of the timing signal appear is switched. The generated timing signal is sequentially inputted to the latch A815 on the first stage. When, the timing signal is inputted to the latch A815, video signals are sequentially written into the latch A815 in synchronization with the pulse of the timing signal, and then held therein. It should be noted that although the video signals are sequentially written into the latch A815 in this embodiment, the invention is not limited to this. It is also possible to perform a so-called division drive by dividing the latch A815 which has multiple stages into several groups, and inputting a video signal to each group in parallel. The number of groups at this time is referred to as the number of division. For example, when dividing the latch into four groups of stages, it is said that division drive is performed with four divided groups.

[0095]

A period through which writing of video signals to all stages of the analog latch A815 is completed is referred to as a line period. A line period in actuality may include the total period of the above line period and a horizontal fry-back period in some cases.

[0096]

When one line period has terminated, a latch signal (Latch Signal) is supplied to the latch B816 on the second stage. In synchronization with the latch signal, the video signals held in the latch A815 are written into the latch B816 all at once, and then held therein. In the latch A815 which has transferred the video signals to the latch B816, writing of the next video signals are once again started in sequence, in synchronization with timing signals from the shift register

814. During this second line period, the video signals written to and held in the latch B816 are inputted to the pixel portion 811 through signal lines.

[0097]

It should be noted that an alternative circuit capable of selecting a signal line such as a decoder circuit may be used instead of the shift register 814.

[0098]

The signal line driver circuit for driving the light emitting device of the invention is not limited to the configuration shown in this embodiment.

[0099]

(Embodiment 6)

Next, switching of a scan direction and a video signal in the case of switching a display from one screen side to the other screen side is described.

[0100]

Generally, in a light emitting panel in which multiple pixels are arranged in matrix, pixels are selected on a row-by-row basis, to which a video signal is inputted. A driving method in which video signals are sequentially inputted to pixels in one selected row is referred to as a dot sequential drive. Meanwhile, a driving method in which a video signal is inputted to all the pixels in one row at a time is referred to as a line sequential drive. In either of the driving methods, a video signal to be inputted to each pixel always has image data corresponding to the pixel.

[0101]

FIG. 9(A) shows multiple pixels arranged in matrix in a light emitting panel, and image data (D1 to D35) inputted to each pixel. It is assumed that a dot sequential drive is performed in the light emitting panel shown in FIG. 9(A), and a scan direction of scan lines is denoted by a solid arrow as a row scan direction, while the input order of video signals to pixels is denoted by a dotted arrow as a column scan direction.

[0102]

FIG. 9(B) shows a view of the light emitting panel shown in FIG. 9(A) which is seen from the opposite side. On the opposite side shown in FIG. 9(B), a column scan direction is in the direction from left to right which is opposite to the column scan direction from right to left in

FIG. 9(A). Accordingly, the input order of video signals to one row of pixels is opposite.

[0103]

Thus, when switching the display screen, either of the following measures is required to be taken: a column scan direction is switched to the opposite direction, or image data of a video signal is flipped horizontally in accordance with the column scan direction.

[0104]

It should be noted that the configuration of the driver circuit can be simplified in the case of switching image data to be flipped horizontally. In addition, in the case of switching the column scan direction to the opposite direction, the configuration of a controller for processing video signals in accordance with the scan direction of the light emitting panel can be simplified, which in turn can reduce a load on the controller in driving.

[0105]

Assume that a row scan direction of the light emitting panel is inverted so as to display an image on the opposite side of the light emitting panel, for example. At this time, as shown in FIG. 9(C), the row scan direction on the opposite side is in the opposite direction to the row scan direction in FIG. 9(A). Accordingly, the input order of video signals in one row of pixels is inverted. In this case also, either of the following measures is required to be taken: a row scan direction is switched to the opposite direction, or image data of a video signal is flipped vertically in accordance with the row scan direction as in the case of FIG. 9(B).

[0106]

It should be noted that the description is made of the case of a dot sequential drive in this embodiment; however, in the case of a line sequential drive also, the scan direction may be switched or image data of a video signal may be flipped horizontally or vertically in switching of a screen.

[0107]

(Embodiment 7)

In this embodiment, specific configurations of a signal line driver circuit and a scan line driver circuit having a function of switching a scan direction is described.

[0108]

FIG. 10 shows a circuit diagram of a signal line driver circuit of this embodiment. The

signal line driver circuit shown in FIG. 10 corresponds to analog video signals. In FIG. 10, reference numeral 1201 denotes a shift register, which generates a timing signal for determining the sampling timing of a video signal in accordance with a clock signal CK, an inverted clock signal CKb which is inverted from the clock signal CK, and a start pulse signal SP.

[0109]

The shift register 1201 includes multiple flip-flops 1210 and multiple transmission gates 1211 and 1212 corresponding to each flip-flop 1210 in pairs. Switching of the transmission gates 1211 and 1212 is controlled by a switch signal L/R, whereby when one of them is turned ON, the other is turned OFF.

[0110]

When the transmission gate 1211 is ON, the shift register functions as a right-shift-type shift register since a start pulse signal is supplied to the flip-flop 1210 on the leftmost side. On the other hand, when the transmission gate 1212 is ON, the shift register functions as a left-shift-type shift register since a start pulse signal is supplied to flip-flop 1210 on the rightmost side.

[0111]

The timing signal generated in the shift register 1201 is buffer-amplified in multiple inverters 1202, and then transferred to a transmission gate 1203. It should be noted that FIG. 10 shows only one output of the shift register, that is the circuit on the rear stage (the inverter 1202 and the transmission gate 1203 here); however in actuality, multiple circuits corresponding to other outputs are provided on the rear stage.

[0112]

Switching of the transmission gate 1203 is controlled by the timing signal which is buffer-amplified. When the transmission gate 1203 is ON, a video signal is sampled and supplied to each pixel in the pixel portion. In the case where the shift register 1201 functions as a right-shift-type shift register, a column scan direction is from left to right whereas in the case where the shift register 1201 functions as a left-shift-type shift register, the column scan direction is from right to left.

[0113]

FIG. 11 shows a circuit diagram of a signal line driver circuit of this embodiment. The

signal line driver circuit shown in FIG. 11 corresponds to digital video signals. In FIG. 11, reference numeral 1301 denotes a shift register having the same configuration as the shift register 1201 shown in FIG. 10, in which switching of a scan direction is controlled by a switch signal L/R.

[0114]

A timing signal generated in the shift register 1301 is buffer-amplified in an inverter 1302, and then inputted to a latch 1303. It should be noted that FIG. 11 shows only one output of the shift register 1301, that is the circuit on the rear stage (the inverter 1302, the latch 1303, and a latch 1304 here); however in actuality, multiple circuits corresponding to other outputs are provided on the rear stage.

[0115]

The latch 1303 latches a video signal in accordance with a timing signal. Although FIG. 11 shows only one latch 1303, multiple latches 1303 are provided in actuality, and video signals are sequentially latched in accordance with timing signals. The latch order can be switched by a switch signal L/R to be in the direction of left to right in the latch 1303 or right to left in the latch 1303.

[0116]

When video signals are latched in all the latches 1303, the video signals held in the latches 1303 are transferred to the latches 1304 on the rear stage all at once in accordance with a latch signal LAT and its inverted signal LATb. The video signals latched by the latches 1304 are supplied to the corresponding pixels.

[0117]

FIG. 12 shows a circuit diagram of a scan driver circuit of this embodiment. In FIG. 12, reference numeral 1401 denotes a shift register having the same configuration as the shift register 1201 shown in FIG. 10, in which switching of a scan direction is controlled by a switch signal L/R. A timing signal generated in the shift register 1401 is used for selecting pixels in each row.

[0118]

The timing signal generated in the shift register 1401 is buffer-amplified in an inverter 1402, and then inputted to the pixel. It should be noted that FIG. 12 shows only one output of

the shift register 1401, that is the circuit on the rear stage (the inverter 1402 here); however in actuality, multiple circuits corresponding to other outputs are provided on the rear stage.

[0119]

It should be noted that the driver circuits shown in this embodiment are only exemplary driver circuits which can be used for the light emitting device of the invention, and the invention is not limited to them.

[0120]

(Embodiment 8)

FIG. 13(A) shows a configuration of a portable phone which is one of the electronic apparatuses of the invention. A module of the portable phone shown in FIG. 13(A) includes, on a printed wiring board 906, a controller 901, a CPU 902, a memory 911, a power supply circuit 903, an audio processing circuit 929, and a transmitter/receiver circuit 904 as well as other elements such as a register, a buffer, and a capacitor. A light emitting panel 900 is mounted on the printed wiring board 906 by an FPC 908. The light emitting panel 900 includes a pixel portion 905 in which a light emitting element is provided in each pixel, a scan line driver circuit 906 for selecting the pixel in the pixel portion 905, and a signal line driver circuit 907 for supplying a video signal to the selected pixel.

[0121]

Power supply voltages, various signals inputted from a keyboard, and the like which are supplied to the printed wiring board 906 are supplied through an interface (I/F) portion 909 of the printed wiring board, in which multiple input terminals are disposed. In addition, an antenna port 910 for transmitting/receiving signals to/from an antenna is provided on the printed wiring board 906.

[0122]

It should be noted that the printed wiring board 906 is mounted on the light emitting panel 900 through the FPC in this embodiment; however, the invention is not limited to this. It is also possible to directly mount the controller 901, the audio processing circuit 929, the memory 911, the CPU 902, and the power supply circuit 903 on the light emitting panel 900 by using a COG (Chip on Glass) method.

[0123]

In the printed wiring board 906, in some cases, noise interference on a power supply voltage and signals may occur, or the rising edge of signals may be delayed due to a capacitance formed between lead wirings, resistance of the wirings itself, and the like. Such noise interference on a power supply voltage and signals, and the delayed rising edge of signals can be avoided by providing various elements such as a capacitor and a buffer on the printed wiring board 906.

[0124]

FIG. 13(B) is a block diagram of the module shown in FIG. 13(A).

[0125]

In this embodiment, a memory 911 includes a VRAM 932, a DRAM 925, a flash memory 926, and the like. The VRAM 932 stores image data displayed on the light emitting panel, the DRAM 925 stores image data or audio data, and the flash memory stores various programs.

[0126]

In the power supply circuit 903, power supply voltages to be supplied to the light emitting panel 900, the controller 901, the CPU 902, the audio processing circuit 929, the memory 911, and the transmitter/receiver circuit 931. Depending on the specification of the light emitting panel, the power supply circuit 903 may be provided with a current source in some cases.

[0127]

The CPU 902 includes a control signal generating circuit 920, a decoder 921, a register 922, an arithmetic circuit 923, a RAM 924, a CPU interface 935, and the like. Various signals inputted to the CPU 902 through the interface 935 are once held in the register 922, and then inputted to the arithmetic circuit 923, the decoder 921, and the like. The arithmetic circuit 923 performs an arithmetical operation based on the inputted signal, and specifies a location to transfer various commands. Meanwhile, the signal inputted to the decoder 921 is decoded, and then inputted to the control signal generating circuit 920. The control signal generating circuit 920 generates signals including various commands based on the inputted signal, and transfers them to the location specified by the arithmetic circuit 923, specifically such as the memory 911, the transmitter/receiver circuit 931, the audio processing circuit 929, and the controller 901.

[0128]

The memory 911, the transmitter/receiver circuit 931, the audio processing circuit 929, and the controller 901 each operate in accordance with the received command. Operation thereof is described in brief below.

[0129]

A signal inputted from a keyboard 931 is transferred to the CPU 902 mounted on the printed wiring board 906 through the interface 909. The control signal generating circuit 920 transforms image data stored in the VRAM 932 into a predetermined format in accordance with the signal transferred from the keyboard 931, and then transfers it to the controller 901.

[0130]

The controller 901 performs data processing to a signal including the image data which is transferred from the CPU 902, in accordance with the specification of the light emitting panel, and then supplies it to the light emitting panel 900. The controller 901 generates an Hsync signal, a Vsync signal, a clock signal CLK, an alternating voltage (AC Cont), and a switch signal L/R based on the power supply voltage inputted from the power supply voltage 903 and various signals inputted from the CPU, and then supplies them to the light emitting panel 900.

[0131]

The transmitter/receiver circuit 904 processes a signal which is transmitted/received as a radio wave in the antenna 933, and specifically, it includes a high-frequency circuit such as an isolator, a bandpass filter, a VCO (Voltage Controlled Oscillator), an LPF (Low Pass Filter), a coupler, and a balun. Of the signals transmitted/received to/from the transmitter/receiver circuit 904, a signal including audio data is transferred to the audio processing circuit 929 in accordance with the command from the CPU 902.

[0132]

The signal including audio data which is transferred in accordance with the command from the CPU 902 is demodulated into an audio signal in the audio processing circuit 929, and then transferred to the speaker 928. An audio signal transferred from a microphone 927 is modulated in the audio processing circuit 929, and transferred to the transmitter/receiver circuit 904 in accordance with the command from the CPU 902.

[0133]

The controller 901, the CPU 902, the power supply circuit 903, the audio processing circuit 929, and the memory 911 can be mounted as a package of the invention. The invention can be applied to any circuits other than a high-frequency circuit such as an isolator, bandpass filter, a VCO (Voltage Controlled Oscillator), an LPF (Low Pass Filter), a coupler, and a balun.

[0134]

(Embodiment 9)

In this embodiment, the light emitting device of the invention using a flexible substrate is described. A light emitting device using a flexible substrate is thin and lightweight, and furthermore, it can be used for a display having a curved surface, a show window, and the like. Therefore, it can be applied not only to portable devices, but can be applied to a broad range of devices.

[0135]

FIG. 14 shows a view of light emitting device formed by using a flexible substrate, which is curved. A pixel portion 5002, a scan line driver circuit 5003, and a signal line driver circuit 5004 are formed over a substrate 5001. The substrate 5001 is formed by using a material capable of standing a processing temperature in later steps.

[0136]

It should be noted that various semiconductor elements used for the pixel portion 5002, the scan line driver circuit 5003, and the signal line driver circuit 5004 are not necessarily formed over the substrate 5001 directly, but can be once formed on a heat-resistant substrate so as to be transferred to another flexible substrate which is separately provided. In that case, various methods can be adopted for the transfer such as a method of providing a metal oxide film between the substrate and the semiconductor elements, whereby the metal oxide film is weakened by crystallization so as to peel and transfer the semiconductor elements, a method of providing an amorphous silicon film containing hydrogen between the substrate and the semiconductor elements, whereby the amorphous silicon film is removed by laser light irradiation or etching so as to peel and transfer the semiconductor elements from the substrate, or a method of removing the substrate, over which the semiconductor elements are formed, mechanically or by etching with a solution or gas so as to separate and transfer the semiconductor elements from the substrate.

[0137]

(Embodiment 10)

The light emitting device of the invention can be used for various electronic apparatuses. In particular, the light emitting device of the invention can be effectively applied to portable electronic apparatuses, because the usability can be drastically enhanced by achieving weight saving, downsizing, and enlargement of a display screen. FIG. 15 shows examples of the electronic apparatuses of the invention.

[0138]

FIG. 15(A) is a portable information terminal (PDA) including a main body 2101, a housing 2102, a display portion 2103, an operating key 2104, an antenna 2105, and the like. As shown in FIG. 15(A), the dual-emission light emitting device of the invention is applied to the display portion 2103. By rotating the housing 2102 about a hinge 2106 as an axis, the rear side of the display portion 2103 can be exposed. It is also possible to provide a display portion 2107 which uses another light emitting device, in the portion of the main body 2101 overlapping with the housing 2102.

[0139]

FIG. 15(B) is a portable phone including a main body 2201, a housing 2202, display portions 2103 and 2104, an audio input portion 2105, an audio output portion 2106, an operating key 2107, an antenna 2108, and the like. In FIG. 15(B), the dual-emission light emitting display device of the invention can be applied to the display portions 2103 and 2104.

[0140]

FIG. 15(C) is an electronic book including a main body 2301, a housing 2302, a display portion 2303, an operating key 2304, and the like. In addition, a modem can be incorporated in the main body 2301. The dual-emission light emitting device of the invention is applied to the display portion 2202.

[0141]

As described above, the application range of the invention is so wide that it can be applied to electronic apparatuses in various fields. The electronic apparatuses of this embodiment can employ a light emitting device having any of the configurations shown in Embodiments 1 to 9.

[0142]

[Effect of the Invention]

By using the light emitting device of the invention which is capable of performing display on opposite screen sides, downsizing and weight saving of the light emitting device can be advanced while enlarging an area capable of displaying an image. A full color display with the use of a color filter is the existing technology which has been established in a liquid crystal display device, and it has the advantage of being applied to a light emitting device easily. Further, it has another advantage that precise selective coating of electroluminescent materials with a shadow mask is not required, unlike the method of performing a full color display by using light emitting elements which correspond to the three primary colors, thus luminance variations over time is uniform among all the colors. Unlike the case of a CCM method in which blue light is converted into green or red light by using a color conversion material (CCM) formed of a fluorescent material, there is no concern that the purity of a red color might be decreased due to low color conversion efficiency, or that a pixel might emit light due to outside light such as sunlight because of the color conversion material itself being a fluorescent body, which would result in a low contrast.

[Brief Description of the Drawings]

[FIG. 1] Diagrams each showing a cross sectional structure of a light emitting device.

[FIG. 2] Views each showing a structure of a light emitting device using polarizing plates.

[FIG. 3] Views each showing a structure of a light emitting device using liquid crystal panels.

[FIG. 4] Circuit diagrams each showing a pixel of a light emitting device.

[FIG. 5] Diagrams each showing a cross sectional structure of a light emitting element.

[FIG. 6] Circuit diagrams each showing a pixel of a light emitting device.

[FIG. 7] Diagram showing a cross sectional structure of a pixel of a light emitting device.

[FIG. 8] Block diagrams each showing a configuration of a light emitting device.

[FIG. 9] Diagrams each showing a switching of a scan direction.

[FIG. 10] Circuit diagram of a signal line driver circuit.

[FIG. 11] Circuit diagram of a signal line driver circuit.

[FIG. 12] Circuit diagram of a scan line driver circuit.

[FIG. 13] Diagrams each showing a configuration of a module of a light emitting device provided in a portable phone.

[FIG. 14] View of a light emitting panel using a flexible substrate.

[FIG. 15] Views of electronic apparatuses of the invention.

[Name of Document] Abstract

[Abstract]

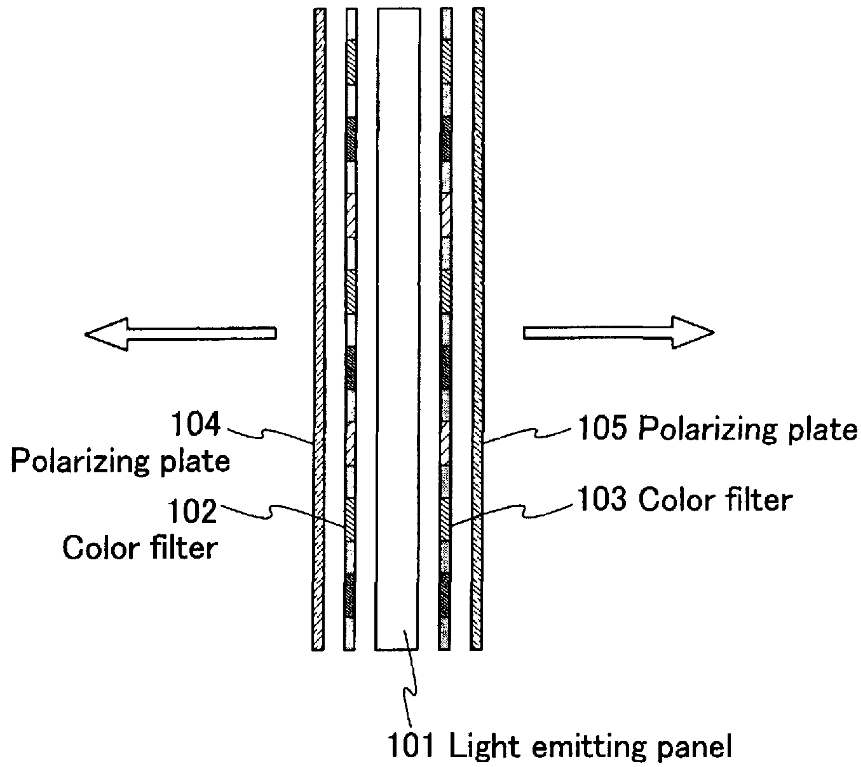
[Object] To achieve weight saving, downsizing, and enlargement of a display screen of an electronic apparatus, in particular a portable electronic apparatus.

[Solution Means] An electronic apparatus using a light emitting device which includes a light emitting element, a color filter provided on one side of an anode or a cathode of the light emitting element, and two polarizing plates sandwiching the light emitting element and the color filter. The anode and the cathode have light transmitting properties, deflection angles of the two polarizing plates are different from each other, and light obtained from the light emitting element is white.

[Selected Drawing] FIG. 1

FIG. 1

(A)


104
Polarizing plate
102
Color filter
105 Polarizing plate
103 Color filter
101 Light emitting panel

(B)

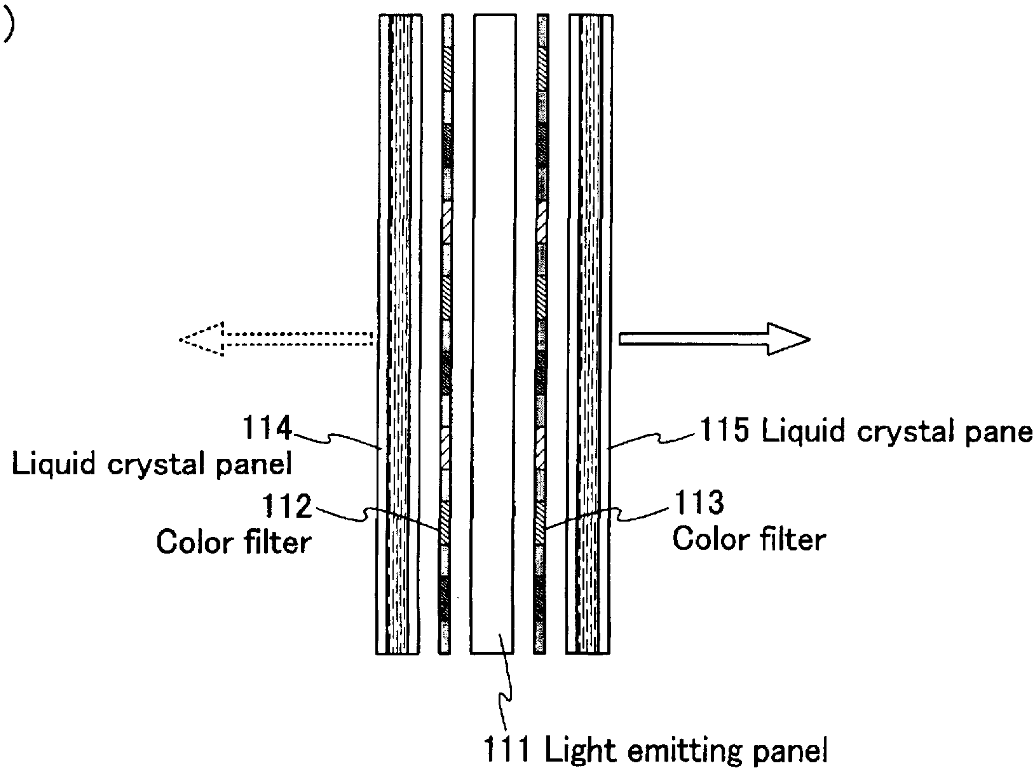
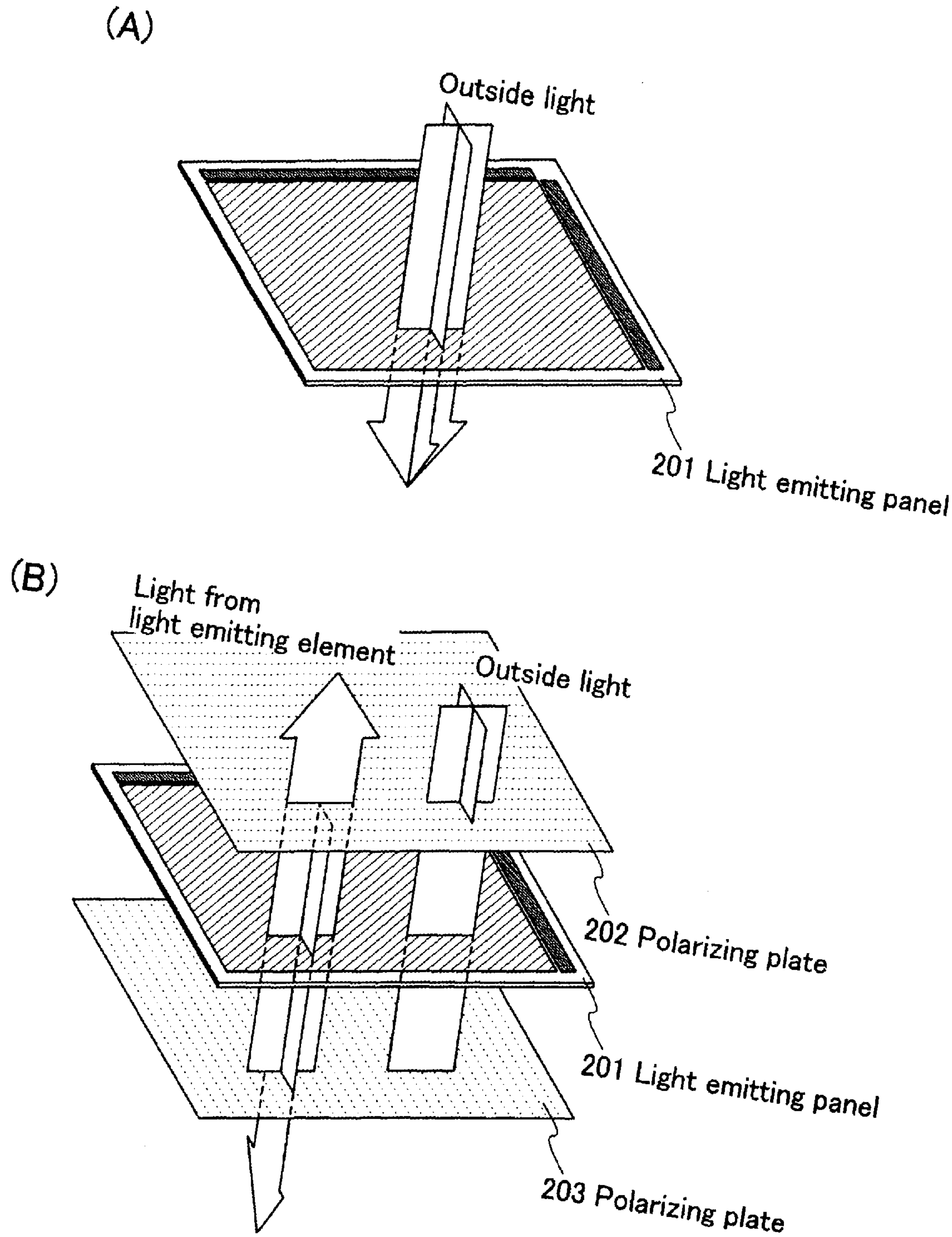

114
Liquid crystal panel
112
Color filter
115 Liquid crystal panel
113
Color filter
111 Light emitting panel

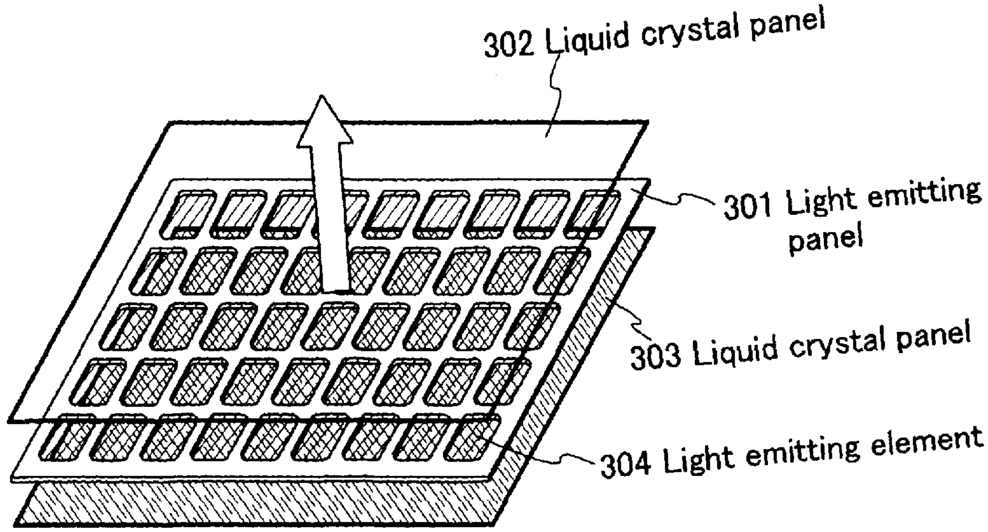
FIG. 2



(A)
Outside light
201 Light emitting panel
(B)
Light from
light emitting element
Outside light
202 Polarizing plate
201 Light emitting panel
203 Polarizing plate

FIG. 3

(A)


302 Liquid crystal panel
301 Light emitting panel
303 Liquid crystal panel
304 Light emitting element

(B)

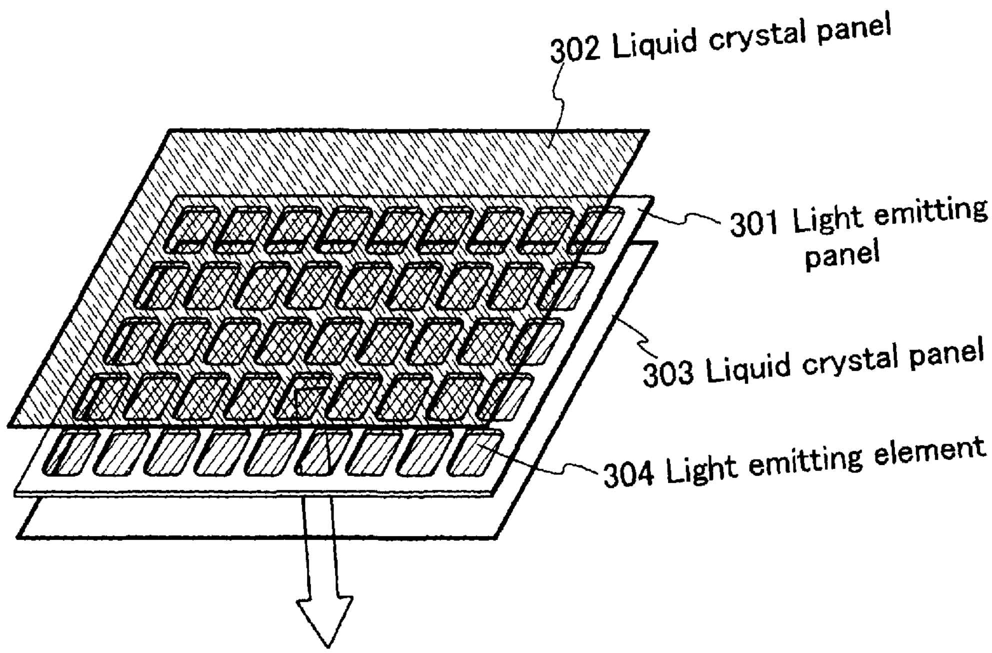
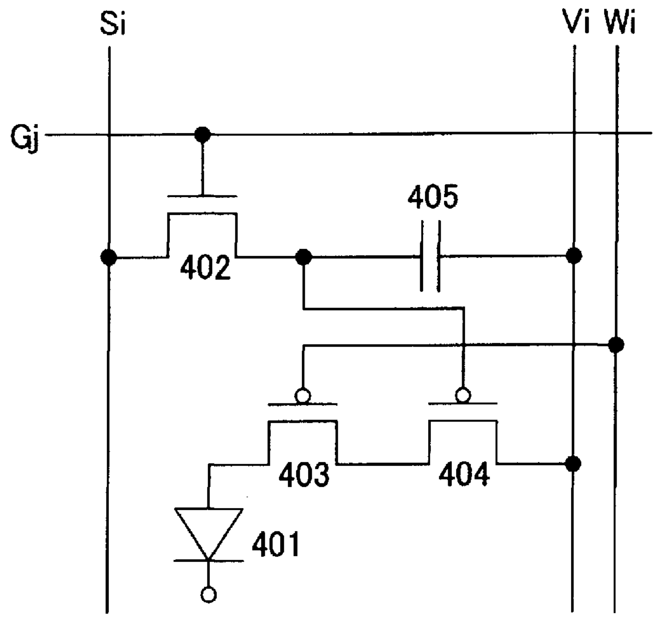

302 Liquid crystal panel
301 Light emitting panel
303 Liquid crystal panel
304 Light emitting element

FIG. 4

(A)


Si
Vi Wi
Gj
405
402
403
404
401

(B)

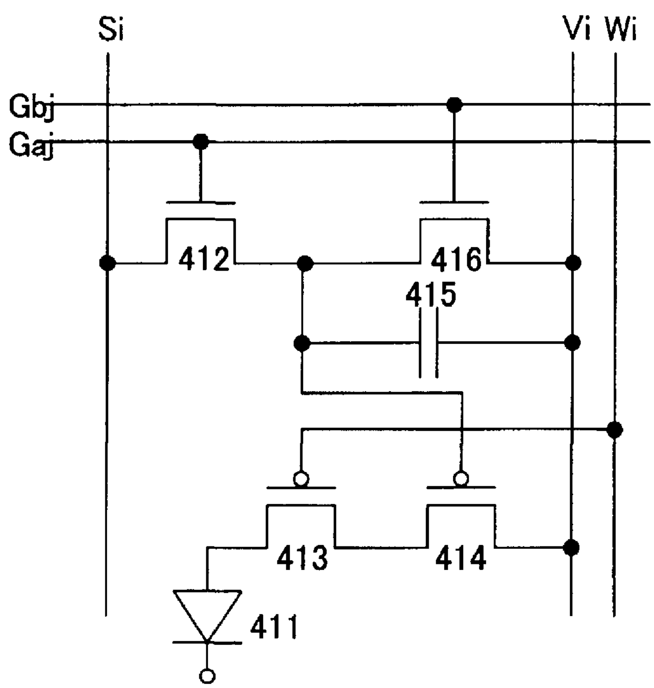

Si
Vi Wi
Gbj
Gaj
412
416
415
413
414
411

FIG. 5

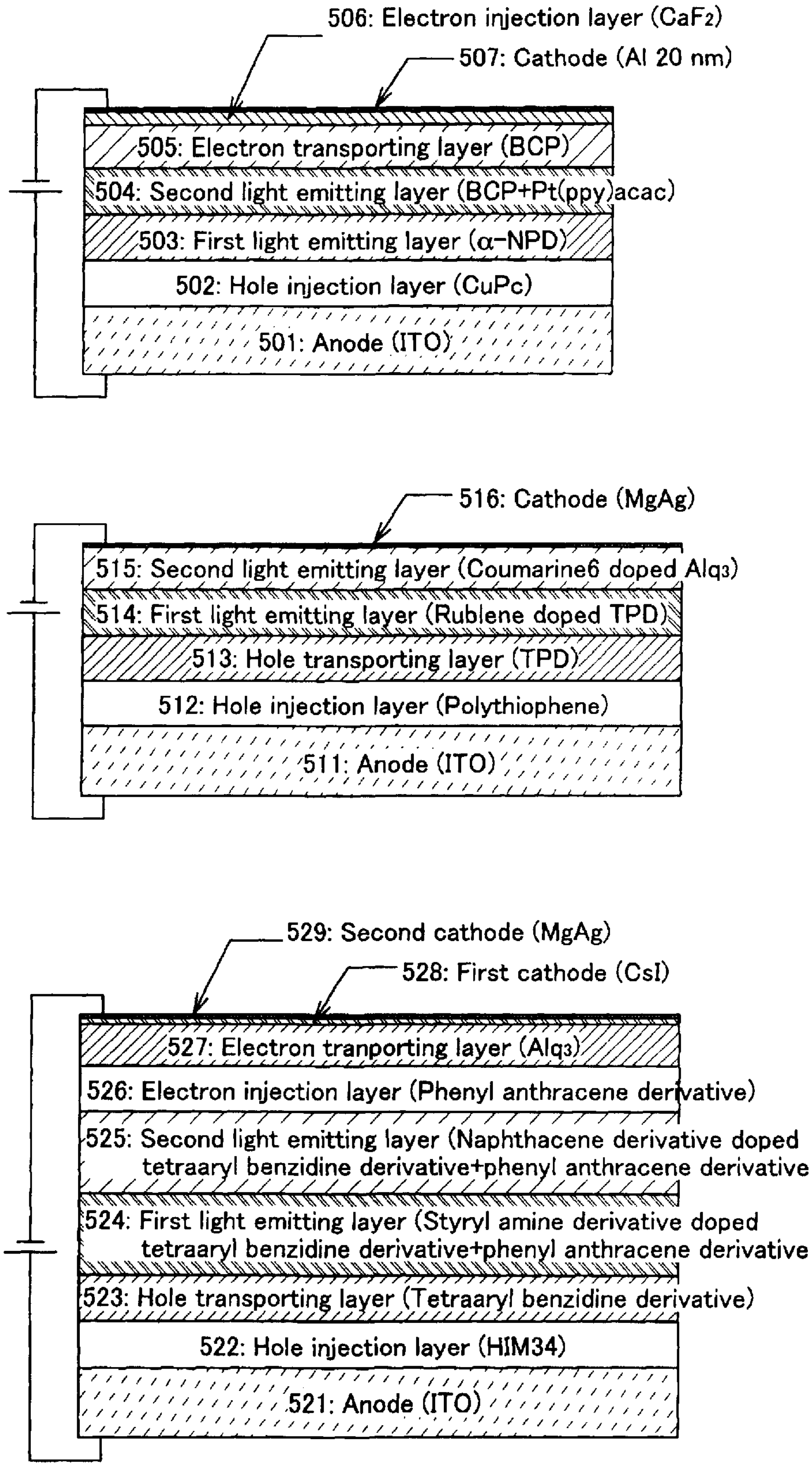

(A)
506: Electron injection layer (CaF_2)
507: Cathode (Al 20 nm)
505: Electron transporting layer (BCP)
504: Second light emitting layer (BCP+Pt(ppy)acac)
503: First light emitting layer (α-NPD)
502: Hole injection layer (CuPc)
501: Anode (ITO)
(B)
516: Cathode (MgAg)
515: Second light emitting layer (Coumarine6 doped Alq_3)
514: First light emitting layer (Rublene doped TPD)
513: Hole transporting layer (TPD)
512: Hole injection layer (Polythiophene)
511: Anode (ITO)
(C)
529: Second cathode (MgAg)
528: First cathode (CsI)
527: Electron tranporting layer (Alq_3)
526: Electron injection layer (Phenyl anthracene derivative)
525: Second light emitting layer (Naphthacene derivative doped tetraaryl benzidine derivative+phenyl anthracene derivative
524: First light emitting layer (Styryl amine derivative doped tetraaryl benzidine derivative+phenyl anthracene derivative
523: Hole transporting layer (Tetraaryl benzidine derivative)
522: Hole injection layer (HIM34)
521: Anode (ITO)

FIG. 6

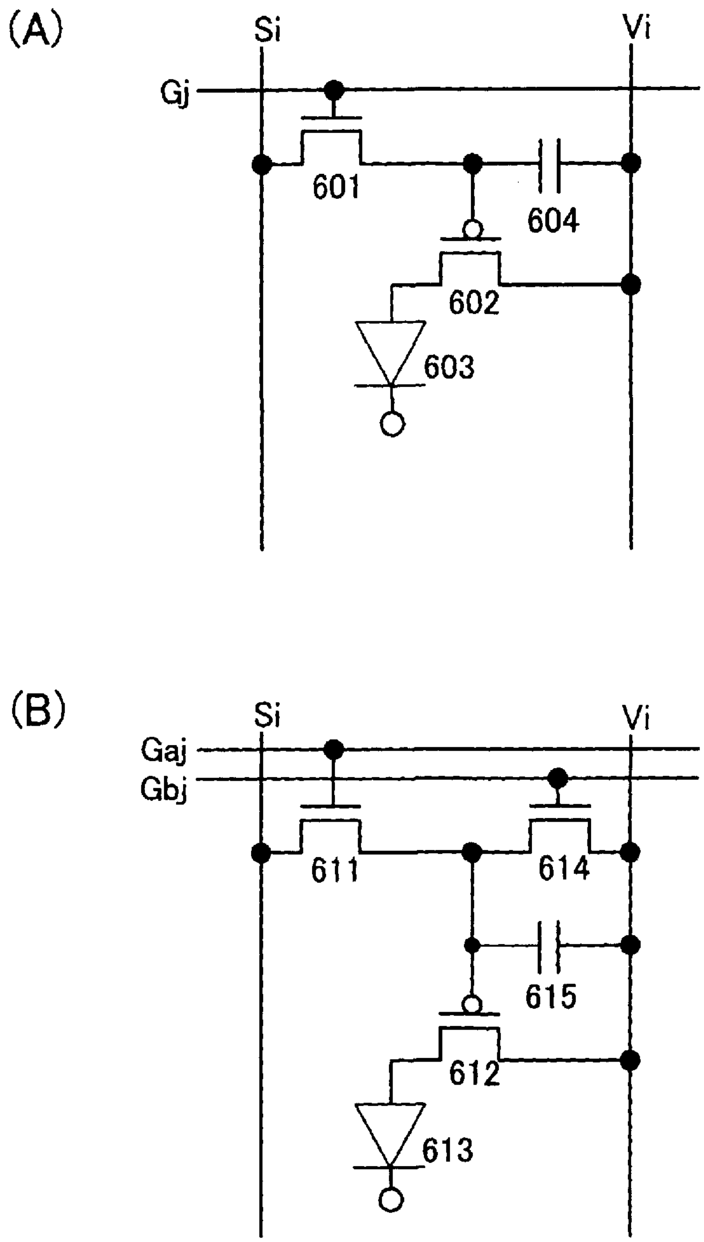
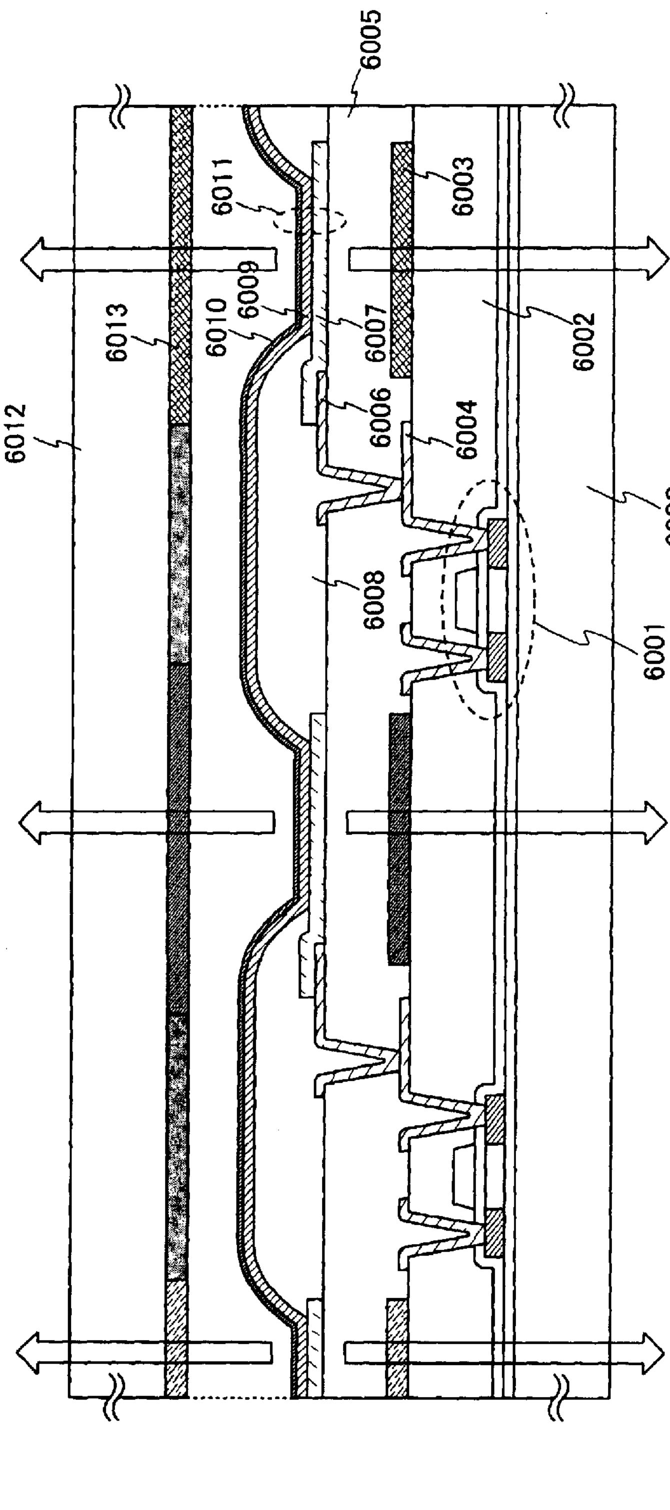


FIG. 7



6005
6011
6003
6013
6010
6009
6007
6002
6006
6004
6012
6000
6008
6001

FIG. 8

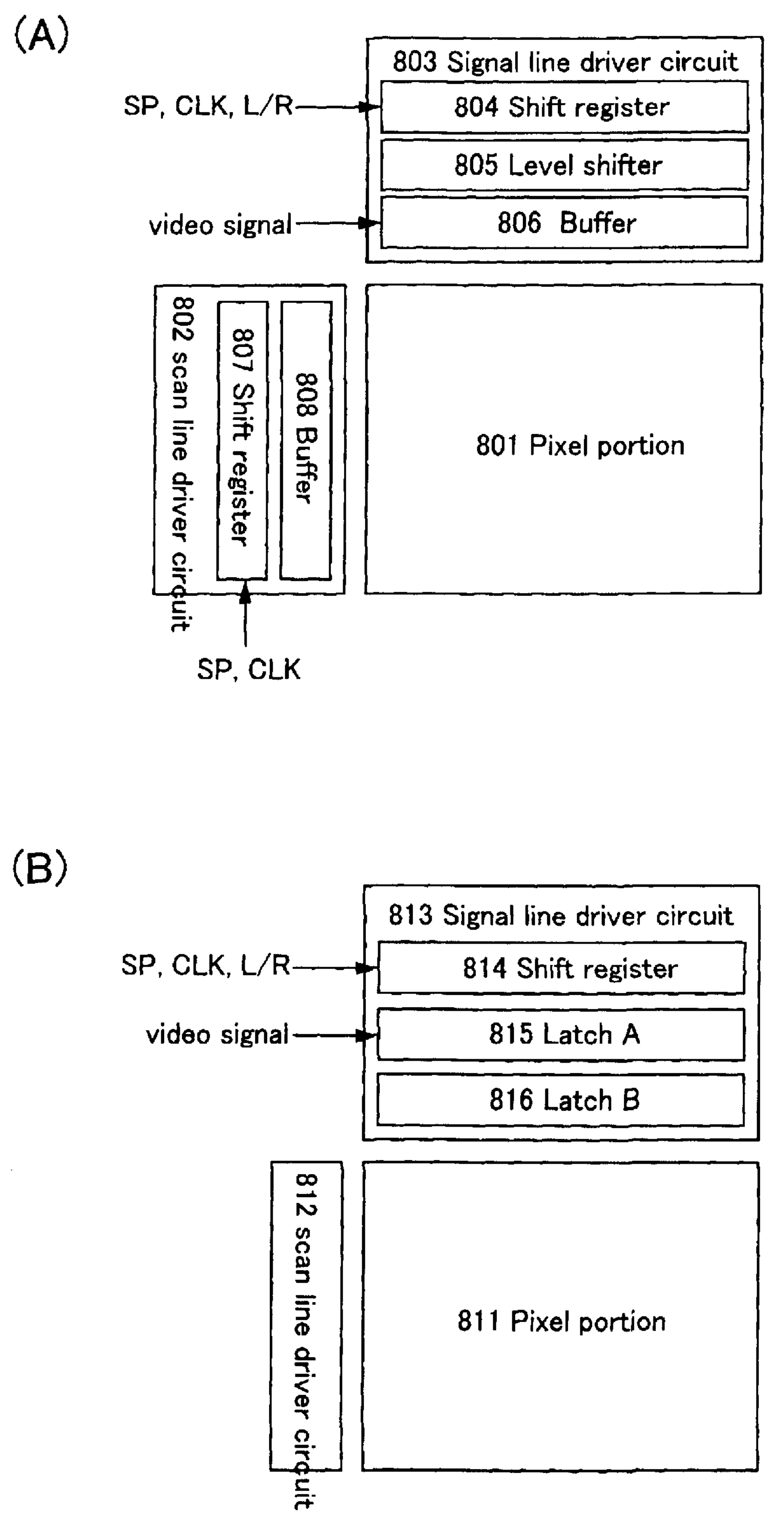

(A)
803 Signal line driver circuit
SP, CLK, L/R
804 Shift register
805 Level shifter
video signal
806 Buffer
802 scan line driver circuit
807 Shift register
808 Buffer
801 Pixel portion
SP, CLK
(B)
813 Signal line driver circuit
SP, CLK, L/R
814 Shift register
video signal
815 Latch A
816 Latch B
812 scan line driver circuit
811 Pixel portion

FIG. 9

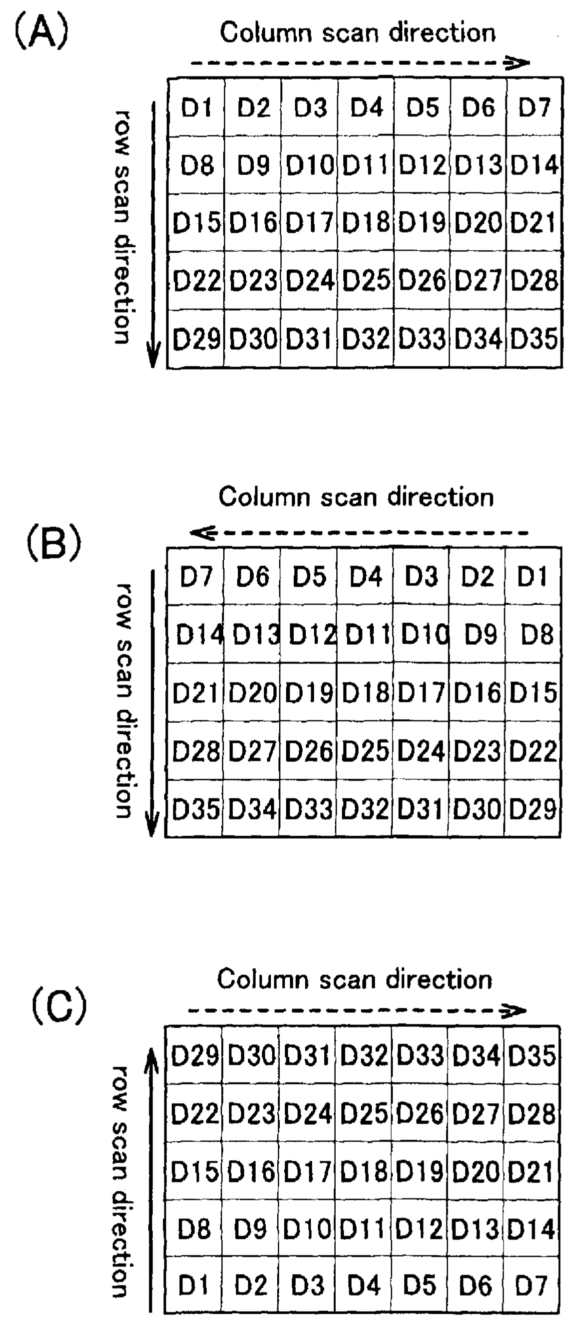
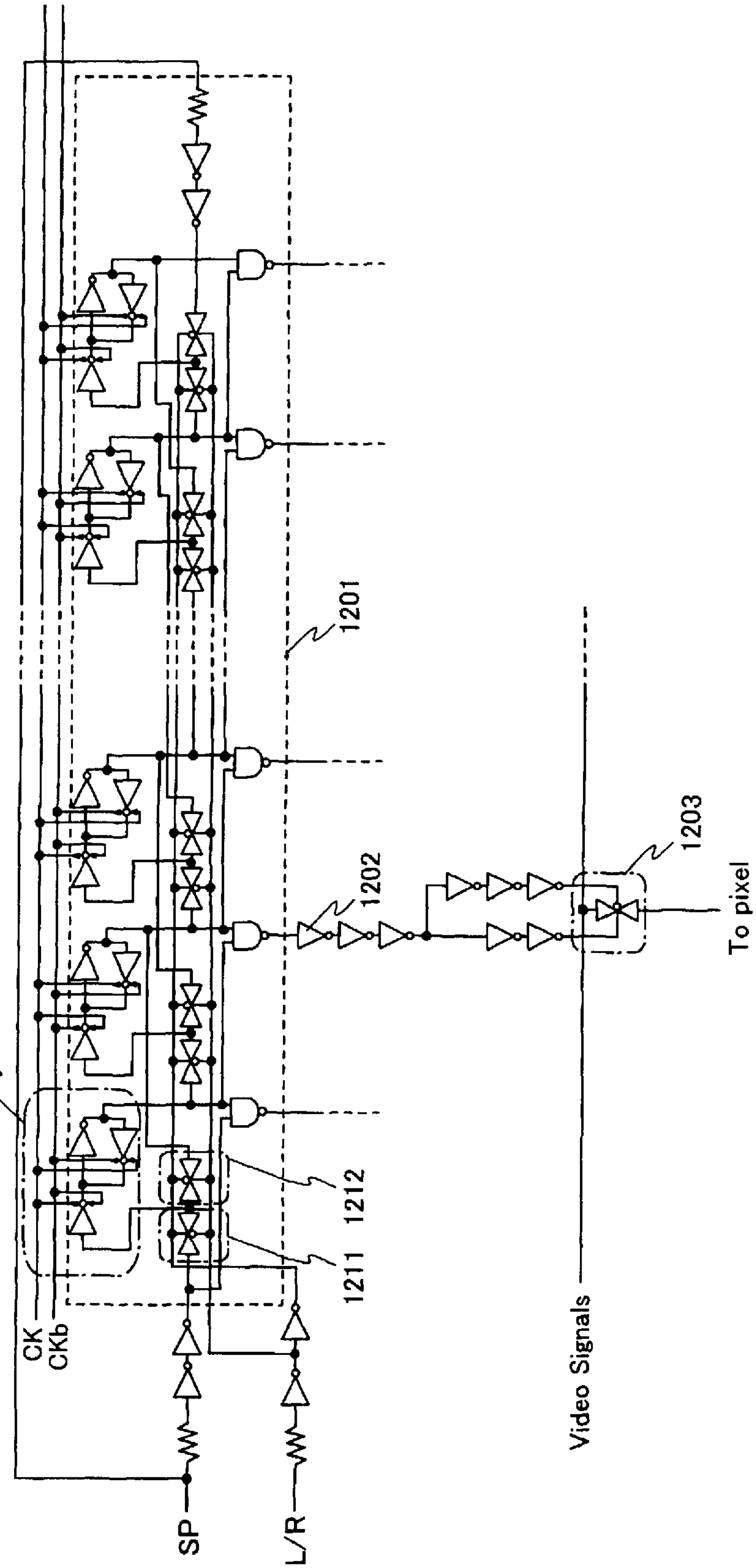
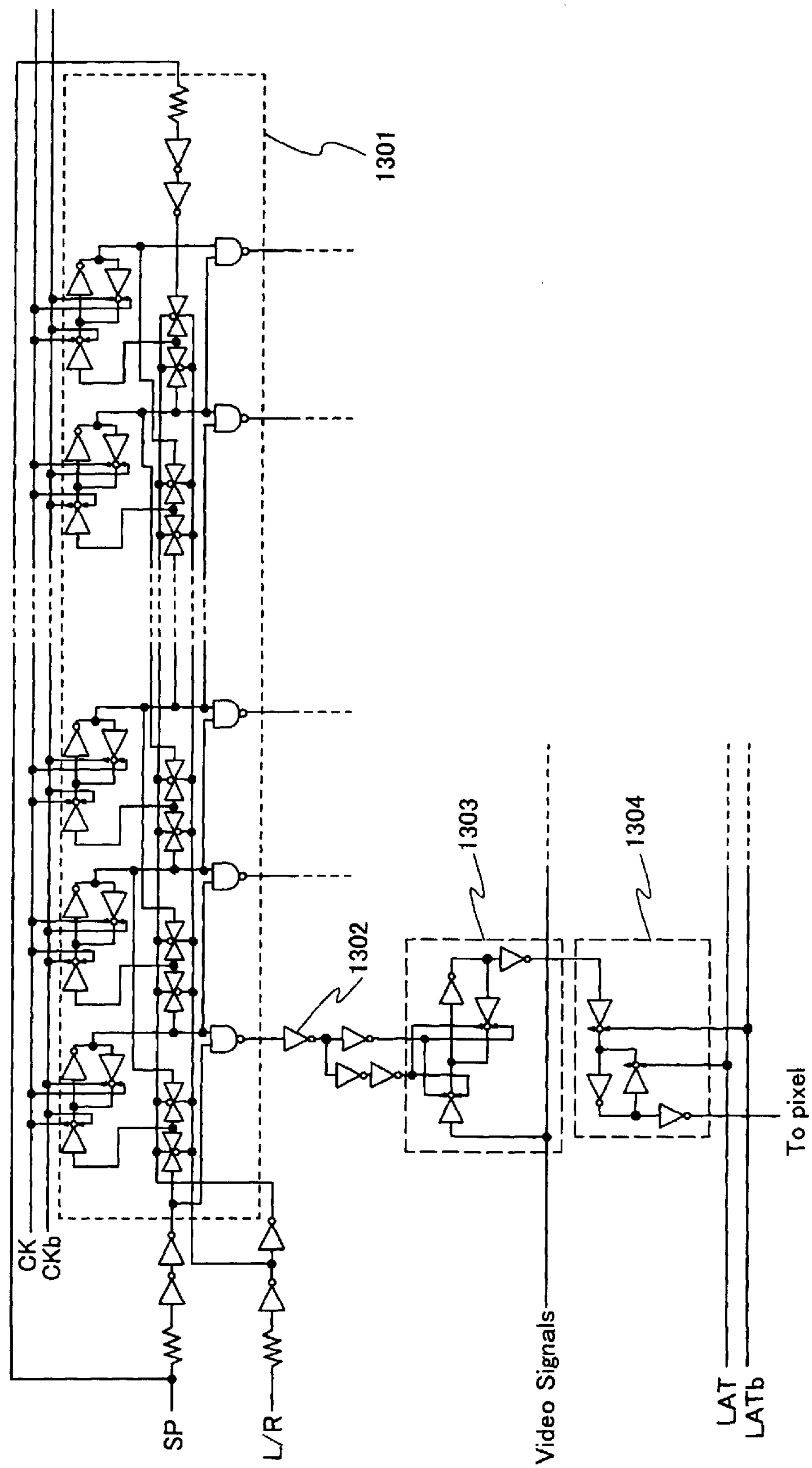

(A)
Column scan direction
row scan direction
D1 D2 D3 D4 D5 D6 D7
D8 D9 D10 D11 D12 D13 D14
D15 D16 D17 D18 D19 D20 D21
D22 D23 D24 D25 D26 D27 D28
D29 D30 D31 D32 D33 D34 D35
(B)
Column scan direction
row scan direction
D7 D6 D5 D4 D3 D2 D1
D14 D13 D12 D11 D10 D9 D8
D21 D20 D19 D18 D17 D16 D15
D28 D27 D26 D25 D24 D23 D22
D35 D34 D33 D32 D31 D30 D29
(C)
Column scan direction
row scan direction
D29 D30 D31 D32 D33 D34 D35
D22 D23 D24 D25 D26 D27 D28
D15 D16 D17 D18 D19 D20 D21
D8 D9 D10 D11 D12 D13 D14
D1 D2 D3 D4 D5 D6 D7

FIG. 10



1201
1202
1203
1210
1211
1212
CK
CKb
SP
L/R
Video Signals
To pixel

FIG. 11



1301
1302
1303
1304
CK
CKb
SP
L/R
Video Signals
LAT
LATb
To pixel

FIG. 12

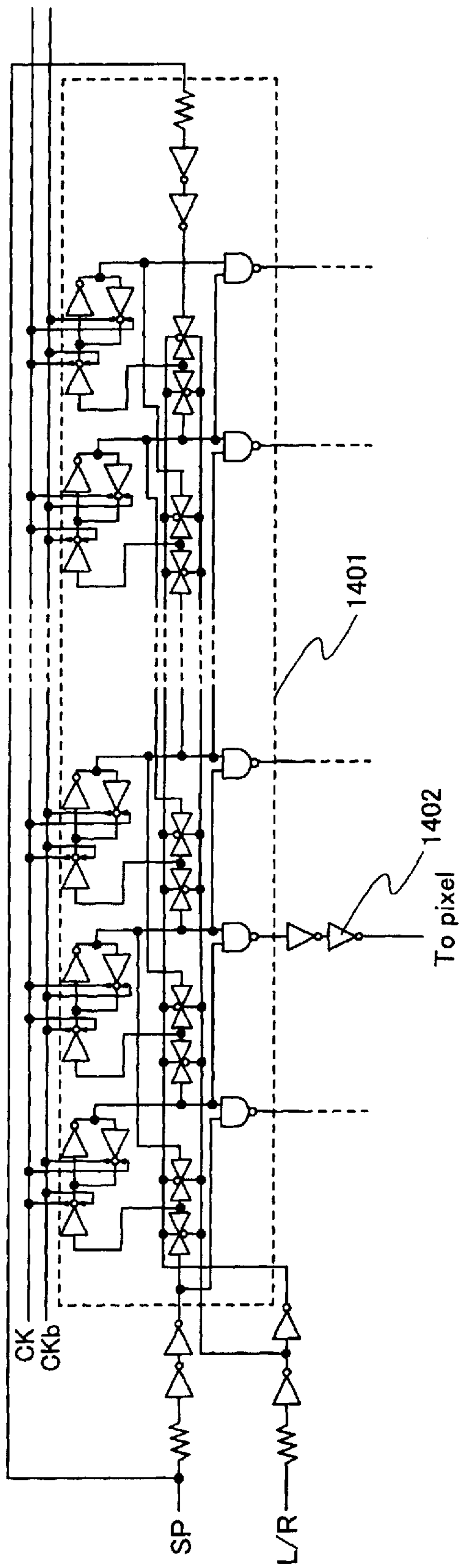
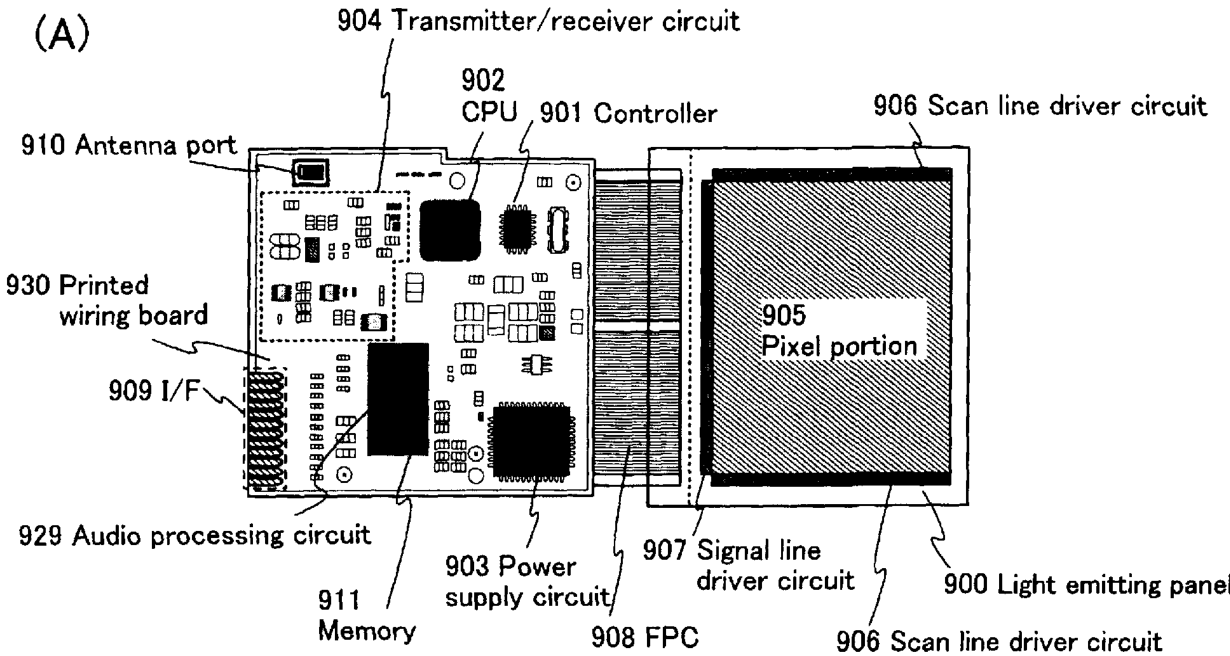


FIG. 13

(A)


904 Transmitter/receiver circuit
902 CPU
901 Controller
906 Scan line driver circuit
910 Antenna port
930 Printed wiring board
909 I/F
905 Pixel portion
929 Audio processing circuit
903 Power supply circuit
907 Signal line driver circuit
900 Light emitting panel
911 Memory
908 FPC
906 Scan line driver circuit

(B)

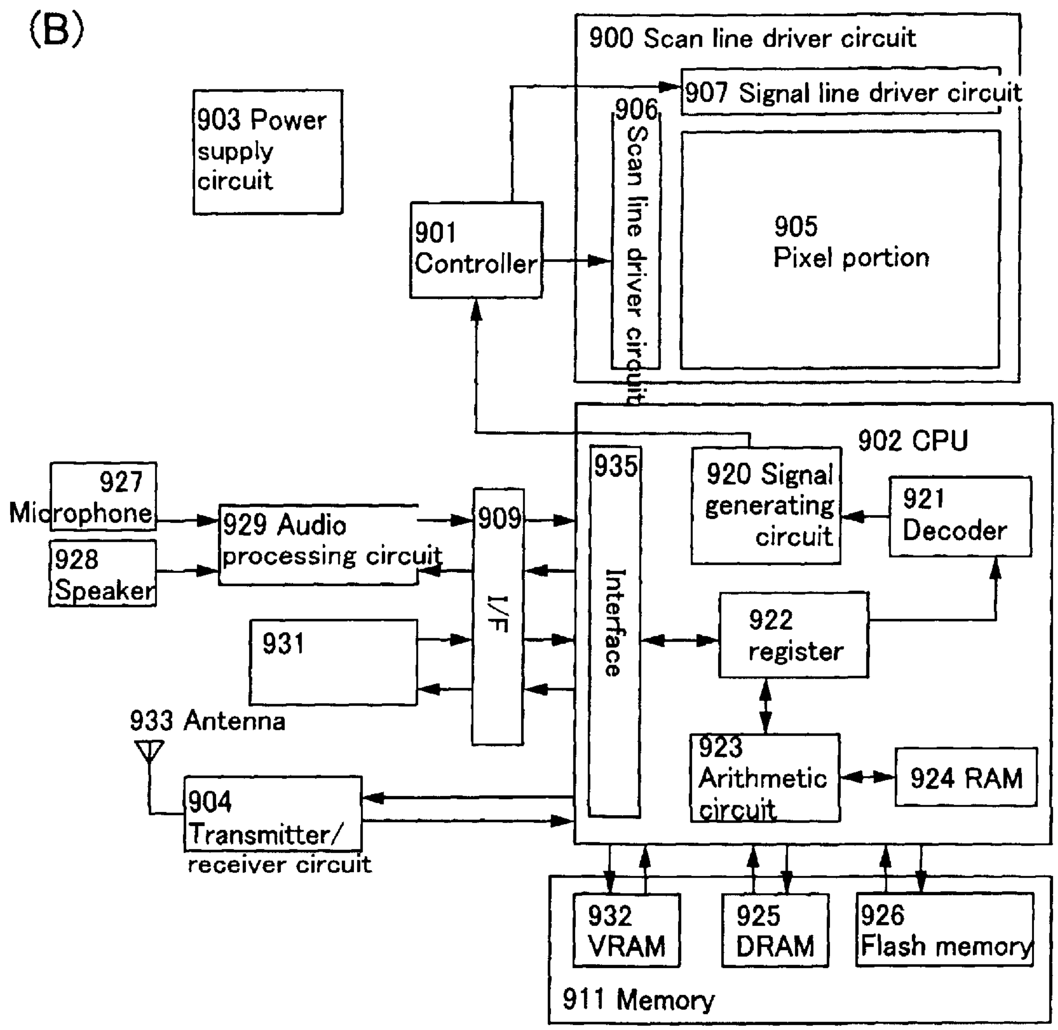

900 Scan line driver circuit
907 Signal line driver circuit
906 Scan line driver circuit
903 Power supply circuit
901 Controller
905 Pixel portion
902 CPU
927 Microphone
928 Speaker
929 Audio processing circuit
909
I/F
935
Interface
920 Signal generating circuit
921 Decoder
922 register
931
933 Antenna
923 Arithmetic circuit
924 RAM
904 Transmitter/ receiver circuit
932 VRAM
925 DRAM
926 Flash memory
911 Memory

FIG. 14

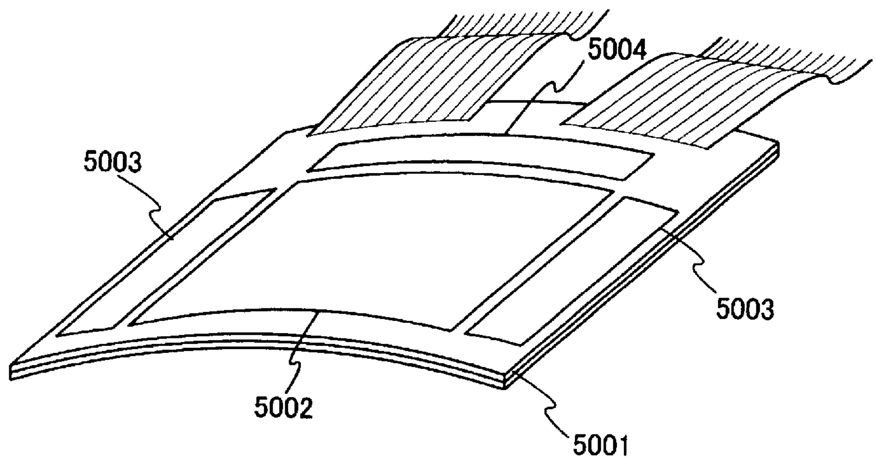
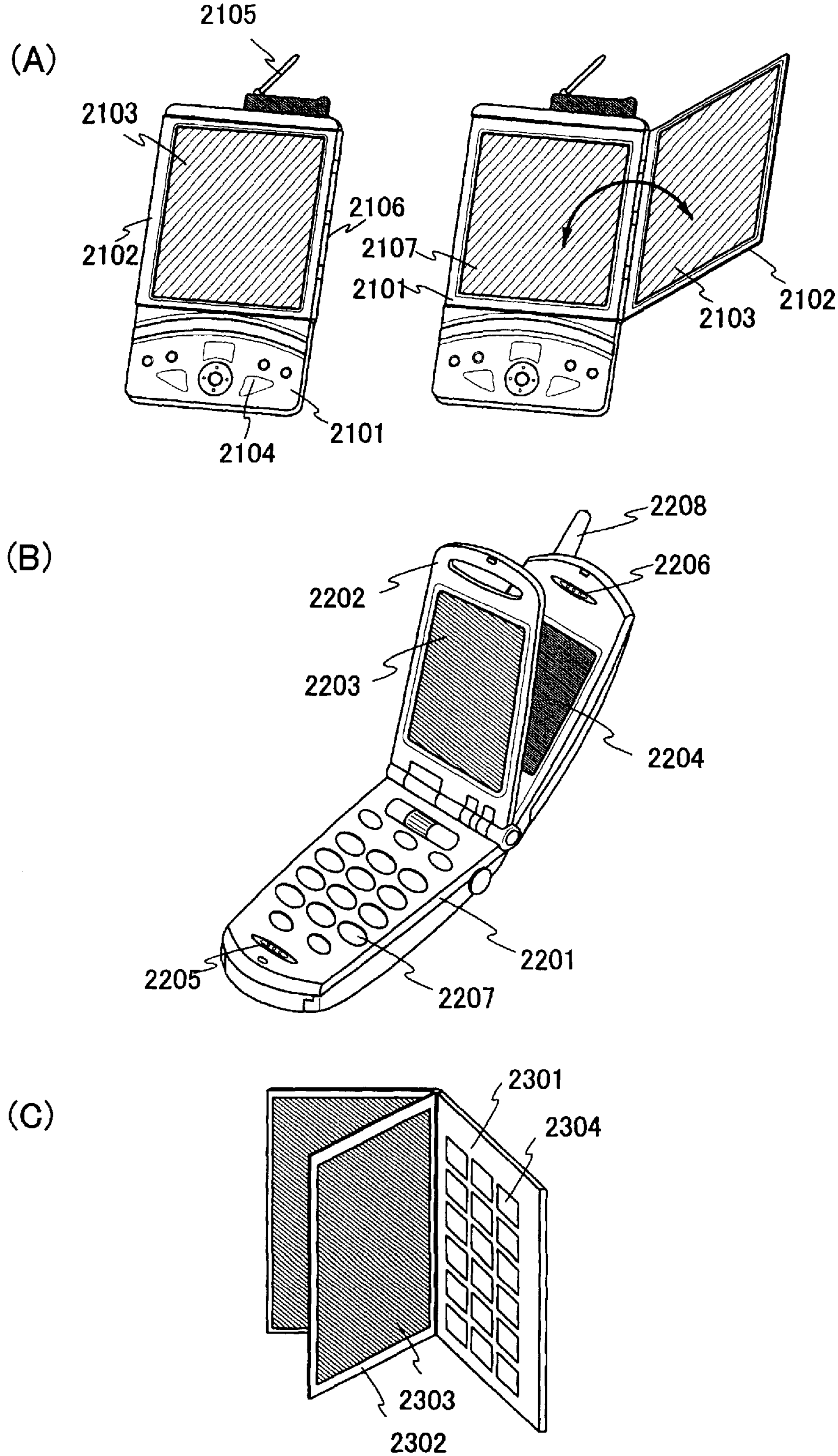


FIG. 15


(A)
2105
2103
2106
2102
2107
2101
2102
2103
2104
2101
(B)
2208
2206
2202
2203
2204
2201
2205
2207
(C)
2301
2304
2303
2302